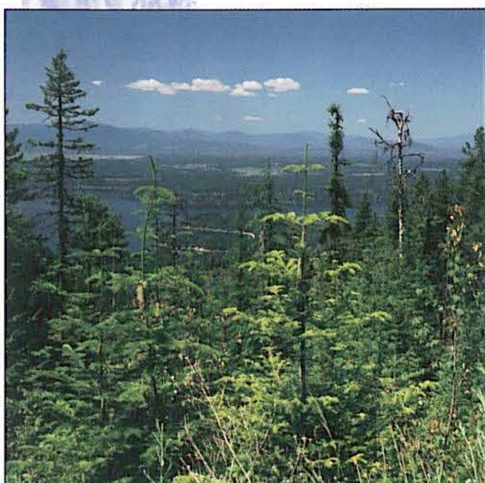
Health of *Idaho's Forests*



A summary of conditions, issues and implications

Health of *Idaho's* *Forests*

May 1999

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IDAHO DEPARTMENT OF LANDS

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

Foreward

The desire for lasting and healthy forests in which to live, work and play is something we all share - not only in Idaho but across our nation. In Idaho we have a number of forest health issues confronting us, our forest ecosystems are not as resilient as desired and the ability to sustain our communities is at risk.

To facilitate effective strategies to resolve these issues we need to have a good inventory of the forest condition and the ability to track changes through time. The nationwide Forest Health Monitoring program initiated in 1990 was the tool designed to provide that information. Idaho Department of State lands, and the three divisions of the USDA Forest Service - Research, National Forest System lands, and State and Private Forestry partnered to produce this comprehensive look at the health of all of Idaho's forests. Idaho was the 19th state added to the program in 1996. The program utilizes existing ongoing information efforts and establishes plots across all forests - Federal, State, and private. From this information Forest Health specialists are able to monitor and assess the long-term status and change in forest conditions. These plots provide scientifically sound information that helps meet the needs of private landowners, policy makers and land managers.

We believe that reasoned decisions can be made about how to manage our forests, by using good information. We hope this publication provides the necessary scientific basis from which private and public land managers and citizens can engage in a meaningful dialogue about the health of Idaho's forests.

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Health of *Idaho's* *Forests*

Introduction

Idaho's image is largely a reflection of its landscapes: its mountains and valleys, rivers and lakes, fields and plains, and especially its forests.

People identify with that landscape and the forests aesthetically and culturally as offering both a desired life-style and/or as a way of making a living.

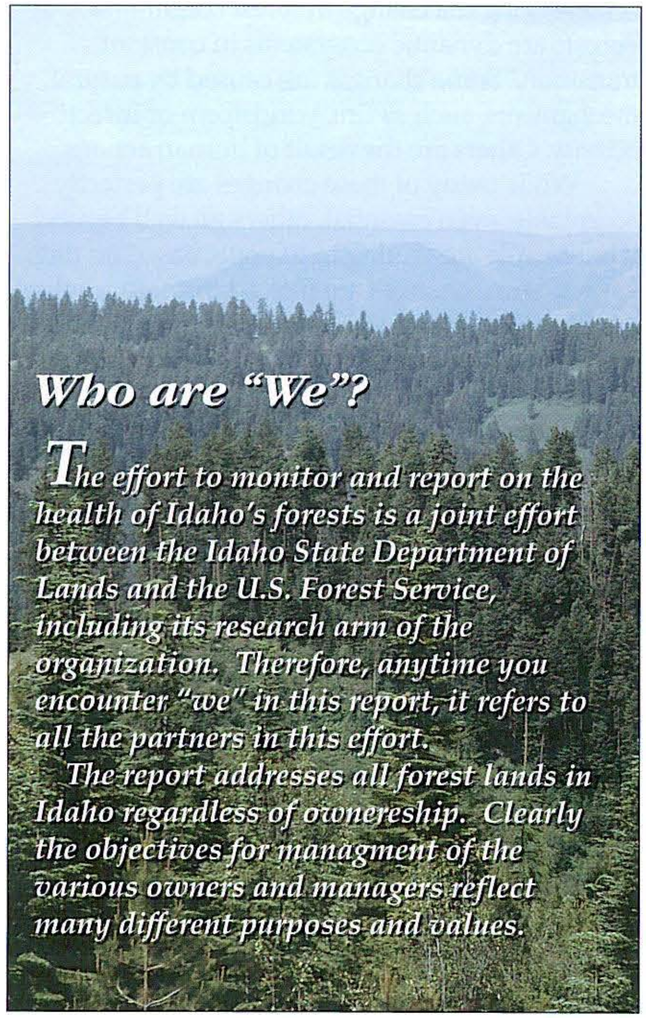
WHAT IS A HEALTHY FOREST?

Regardless of how people view Idaho's forests, the health of these forests is vital. But what is a healthy forest? Healthy compared to what? By what criteria? There are many definitions and concepts because how one views forest health is a reflection of personal values.

In urban forests or in campgrounds, agents of change, like disease, fire, insects and weather damage are often undesirable. They put our facilities as well as visitors at some level of risk. However, in wilderness areas these same elements are considered desired components of a functioning ecosystem. It is our use or objective in managing the forest that determines how we view these agents of change as desirable or undesirable.

In searching for defining elements of a healthy forest, we might consider a forest unhealthy if it loses the ability to maintain or replace its unique species or functions. One way scientists have assessed whether a system is unhealthy is by comparing current conditions with the normal range of dynamics the system has experienced through the past. This concept is referred to as the historic range of variability. Change can be determined using techniques such as permanent monitoring plots, fire history analyses, old historical photo records or studies of pollen and charcoal layers in bogs or lakes. These various pieces of information are then integrated with our understanding of the dynamics of the ecosystem.

The ability of a forest to sustain itself ecologically and provide what society wants and needs is what defines a healthy forest. Maintaining that balance between forest sustainability and production of goods and services is the challenge for owners and managers of the states' forests.



Who are "We"?

The effort to monitor and report on the health of Idaho's forests is a joint effort between the Idaho State Department of Lands and the U.S. Forest Service, including its research arm of the organization. Therefore, anytime you encounter "we" in this report, it refers to all the partners in this effort.

The report addresses all forest lands in Idaho regardless of ownereship. Clearly the objectives for managment of the various owners and managers reflect many different purposes and values.

Two concepts important in defining forest health include (Kolb and others 1994):

Ecological: A healthy forest maintains its unique species and processes, while maintaining its basic structure, composition and function.

Social: A healthy forest has the ability to accommodate current and future needs of people for values, products and services.

These components are inextricably linked. Forests cannot meet social needs without possessing the sustained capacity to grow, reproduce, recycle nutrients, and carry out other ecological functions.

MEASURING FOREST CHANGE

The starting point in evaluating forest health is measuring the change in forest conditions. Forests are dynamic ecosystems in constant transition. Some changes are caused by natural mechanisms, such as fire, windstorm or insect activity. Others are the result of human actions.

While many of these changes are perfectly acceptable, even essential, others go well beyond what people are willing to tolerate, based on their values. Thus, changes are filtered through a value system with subsequent implications.

The purpose of this report is to provide a summary of the changing conditions of Idaho's forests and the issues and implications raised by those changes.

HOW WE MONITOR FOREST HEALTH

Forest Health Monitoring (FHM) is a nationwide program that provides information over the long term on forest conditions, processes and trends. It then interprets what that data means for forest health from a variety of perspectives.

We recognize that forest health is a complex issue. The different sets of criteria used in determining a healthy forest is complex as well. For these reasons, we have included information that will assist you in deciding when a forest is healthy, when it is unhealthy, and why.

Data for this and ensuing reports will come from a variety of sources:

· *The FHM Plot Network*

In 1996, the USDA Forest Service and the Idaho Department of Lands established permanent FHM plots across Idaho's forested lands to gain a baseline measurement of forest conditions. A plot is defined as a permanent sample location, remeasured on a regular cycle.

Within those plots, rigorously trained field crews gathered data on tree diameters, crown conditions, tree damage and lichen communities, all of which are used as indicators of forest health.

In the coming years, crews will remeasure the original set of plots on a four-year cycle, allowing researchers to assess trends in forest conditions. As the program develops, new indicators, such as soil conditions and understory vegetation will be added to supplement the current measurements.

· *Aerial and Ground Surveys*

Aerial Surveys: From aircraft, state or Forest Service observers record detectable tree damage. Tree damage and mortality caused by bark beetles, defoliators, some pathogens (primarily needle or leaf diseases), and weather-related disturbances are monitored annually through aerial detection surveys.

Low level reconnaissance surveys have been conducted over most forested lands in Idaho since the 1950s. The surveys provide an efficient and economical method of detecting and appraising recognizable damage over large forest areas.

Such information is valuable in displaying disturbance trends over time and from place to place. However, many of these damages are extremely variable and often difficult to detect and quantify accurately.

Ground Surveys: Ground surveys are conducted by state and Forest Service specialists to detect and monitor the location, extent, severity, change and trend in large-scale tree damage and mortality caused by insects, pathogens, fire and other agents.

These surveys may include routine field surveillance, insect population sampling, or biological evaluations.

Purpose Specific Permanent plots: For a number of pathogens and insects, plots have been established in infested or susceptible stands to monitor tree damage or mortality rates over time. Such plots provide data to quantify the influence of pathogens and insects on stand composition and structure, and to evaluate effects of treatments.

· *Vegetation Inventories*

Data from a variety of vegetation inventories are available for use in assessing forest health. These include Forest Inventory and Analysis (FIA) data, established by the Forest Service Research branch and available from plots established on all ownerships; National Forest System (NFS) stand and forest inventory data, available for Forest Service lands; timber growth and yield plots maintained by NFS.

Much of the historic data was focused on tree or stand damage, and effects on commodity outputs. Recently, attempts have been made to evaluate forest condition, health and trends. Thus, attempts are underway to use various data to assess not just past damage, but current conditions and to make predictions of future conditions.

In this report, we have attempted to describe conditions broadly and to compare and contrast current conditions with those of the recent past. This description provides a perspective on how forests have changed and offers a basis for predicting trends. The understanding of historic and prehistoric conditions and processes that maintained them provides a useful way to assess unhealthy condition.

Information from these other sources of information is useful in monitoring changes occurring between FHM plots and in assessing the causes of disturbance. Data from the plots can also be used to determine forest areas at risk.

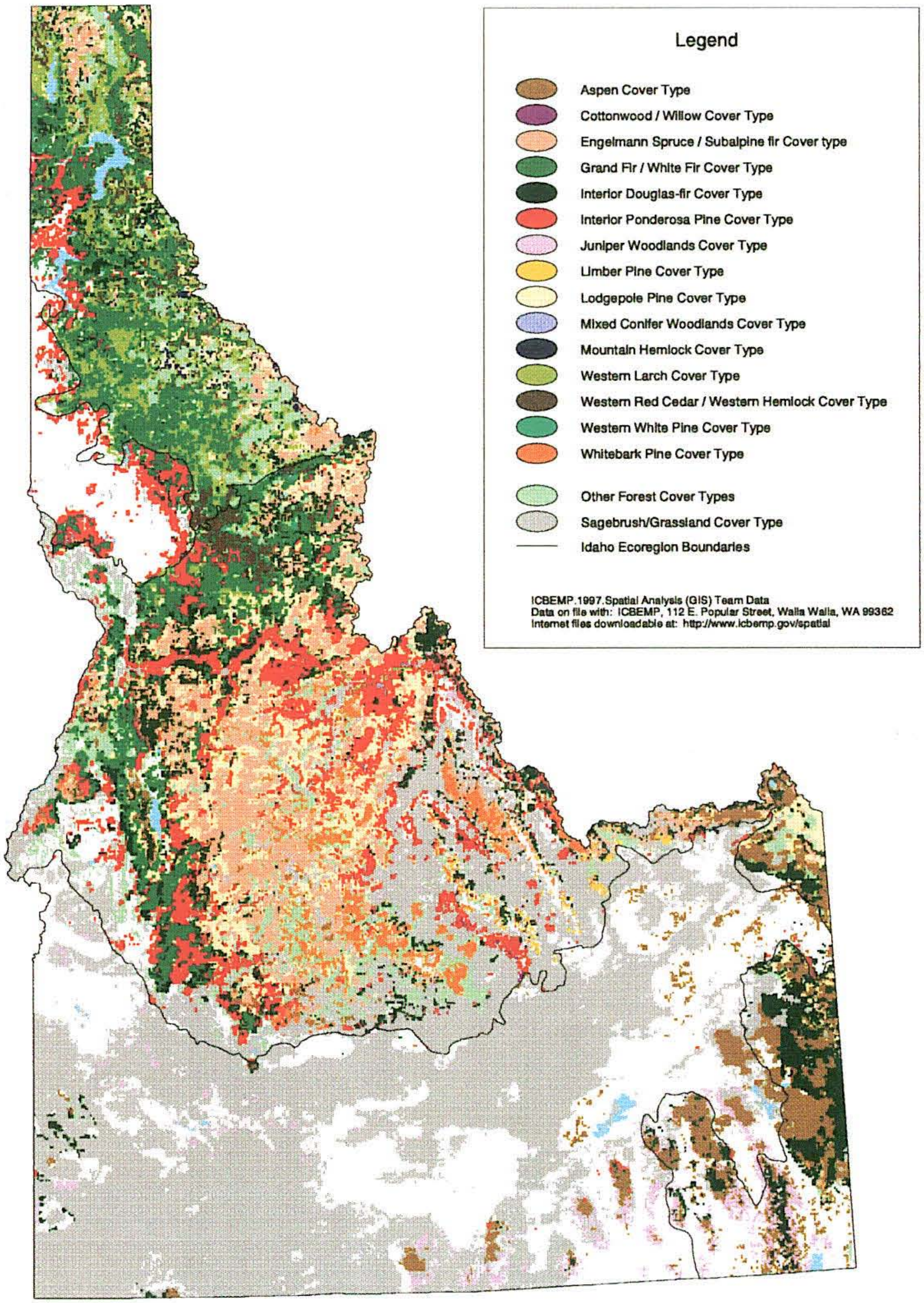
SCOPE OF THIS REPORT

In our investigation of Idaho's forest health issues, it is important to begin with defining the resource ecologically and by ownership.

First, we will describe the state's forest cover and land ownership patterns on a broad scale. Next, we will take a more detailed look at ecological regions, or ecoregions, within the state. Examining ecological divisions are an important step in helping us understand and address forest issues that cross ownership, political and agency boundaries. A brief summary of the data collected on the FHM plot network is included to give you a better idea of forest composition statewide. The body of this report will focus on changing conditions and their important forest-related issues in Idaho. For example, are wildfires a threat or an asset to forest health? What effect do these fires have on human health and safety? Do the answers change with proximity to population centers, or to isolated home sites? Are forests in Idaho similar to those in this region 100 or 200 years ago, or are they changing? If there are changes, how should we view them? Are changes "good" or "bad"? These are difficult questions, with difficult issues underlying them. This report will present some of the more significant issues. However, the ultimate solutions to the problems surrounding forest health will depend largely on public understanding of the trade-offs involved.

We will conclude our study by highlighting those areas of special concern. For those interested in more detailed information, additional tables are presented in the appendices. Please refer to FHM contacts listed in Appendix B for answers to questions or further information.

Figure 1. Forest Types in Idaho.



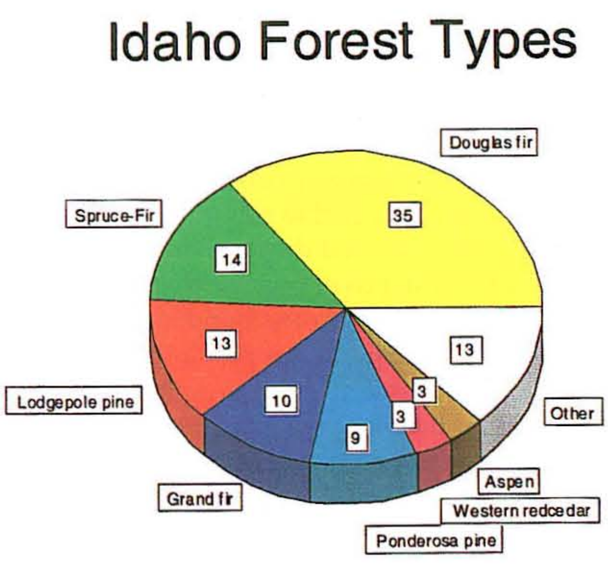
In discussing the health of Idaho's forests, we are dealing with many forests types. From the moist cedar-hemlock forests of the Panhandle to the dry juniper woodlands in Owyhee County, Idaho's forest lands are quite varied. We also will portray that variety in terms of land ownership and ecological regions.

FOREST TYPES

Figure 1 depicts the distribution of forest types across the state of Idaho. In this publication, we use forest type synonymously with cover type, or the dominant tree species at a given site. Forest types are influenced by a number of factors, including climate, elevation, aspect, soil type, and recent disturbance.

The accompanying chart shows the percentages of forested area covered by the primary forest types in the state (Figure 2).

Figure 2.



LAND OWNERSHIP

Figure 3 displays the patterns of forest land ownership in the state, while figure 4 presents land ownership as a percentage of total land.

Figure 3.

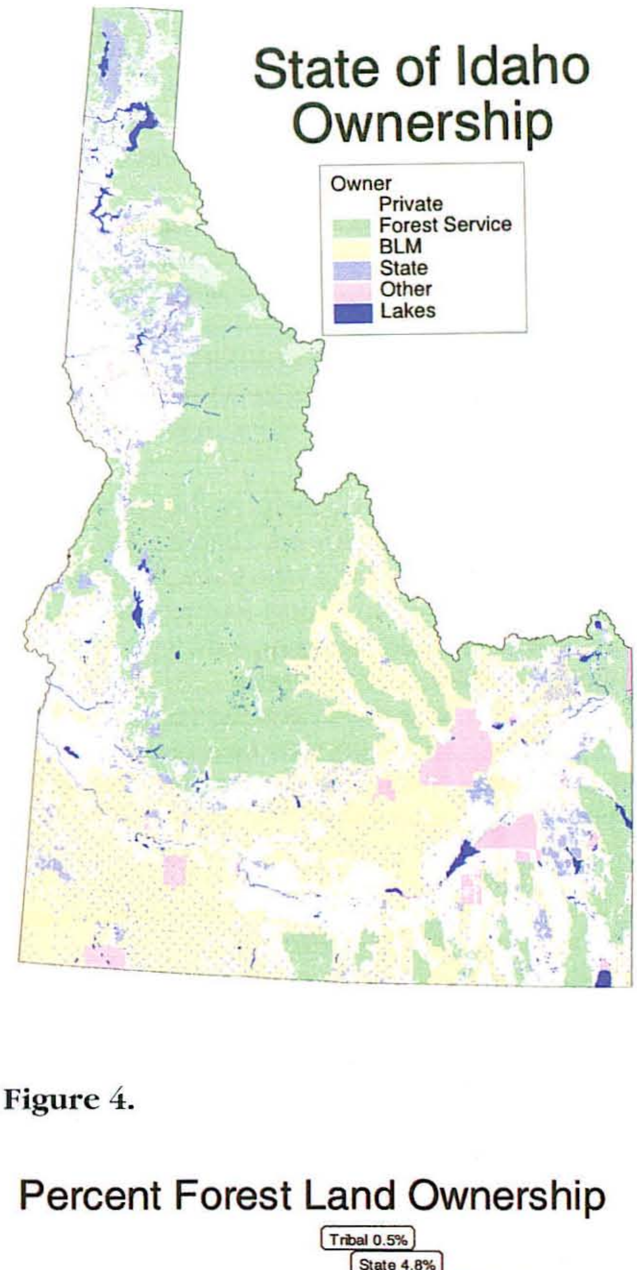
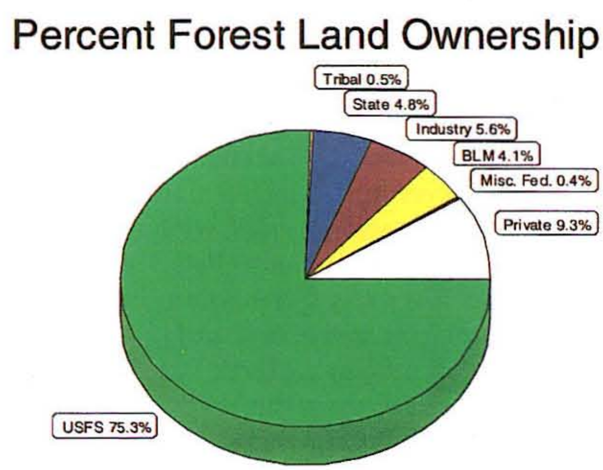


Figure 4.



ECOREGIONS OF IDAHO

As land management agencies and private land owners begin to work together at state and regional scales, it seems logical to approach forest management issues using "ecoregions," or land divisions where ecological conditions are similar.

In recent years, managers have adopted ecologically based land management practices and incorporated mapping systems based on ecological principles.

Bailey's (1995) *Description of the Ecoregions of the United States* presents a hierarchical framework for logically delineating ecological regions based on their unique combinations of physiography, soil type, potential vegetation, and climate. The ecoregions of the United States are delineated, in descending orders of scale, by domains, divisions, provinces, and sections.

In this report we will focus on the ecoregions of Idaho at the province level. There are five distinct provinces found in the state. All of the provinces of Idaho have some forested conditions and, therefore, have been sampled by the FHM plot and aerial survey networks.

Figure 5 shows the distribution of forested sample points across the state by ecoregions. Descriptions of the five ecological provinces of Idaho are discussed below.

Provinces

·Northern Rockies Province: *Northern Rocky Mountain Forest - Steppe - Coniferous Forest -Alpine Meadow Province*

The Northern Rockies are characterized by rugged mountains, separated by flat valley bottoms. Relief within this province ranges from 3000 feet to over 9000 feet. Temperatures can be severe but are often moderated by coastal influences. Precipitation is generally greater than throughout the rest of the Rocky Mountain region, averaging between 16-100 inches annually. Most of the moisture comes in the fall, winter, and spring, while summers remain relatively dry

Soils are less rocky than surrounding mountain provinces in the West and have a distinct volcanic influence. These factors provide excellent soil conditions in the Northern Rockies, and have a direct effect on the abundance of forest biomass.

Vegetation in this province is unique to the Inland West primarily because of precipitation and soil patterns which more closely resemble the Pacific Northwest. Prior to European settlement much of this area was almost entirely forested.

Today, the most common forest types are Douglas-fir, grand fir, and cedar-hemlock. The forest understory is characterized by a lush cover of ferns, forbs, and regenerating trees. Certain lichens are also quite rich in comparison to other ecoregions of Idaho.

·Great Plains Province: *Palouse Dry Steppe Province*

This province comprises the Idaho portion of the Palouse region, which extends into eastern Washington. Its topography is characterized by rolling hills and flatlands, ranging in elevation from below 1000 to about 4000 feet. The lowest point in the state, at Lewiston, is 739 feet above sea level.

Average annual precipitation is about 15 inches, with most of that coming in the form of winter rain or snow, and sporadic spring and summer thunderstorms. The lack of forested environments is due mainly to the rain shadow effect of the Cascade Range to the west and, secondarily, to land clearing by humans.

Also known as the shortgrass prairie, the Palouse is a much smaller "sister province" to the Great Plains ecoregion. The vegetation is composed primarily of grasses, forbs, and small shrubs. (A "steppe" is a grass-covered semiarid plain.)

The forested component of the Palouse is small and mostly confined to moisture-holding aspects, or exposures, and draws. Forested areas include scattered stands of ponderosa pine and Douglas-fir. Cottonwoods are found along riparian zones throughout this province. Much of the Palouse has been converted to agricultural or urban uses and therefore will not reflect the native plant communities described for this province.

· Middle Rockies Province: *Middle Rocky Mountain Steppe - Coniferous Forest - Alpine Meadow Province*

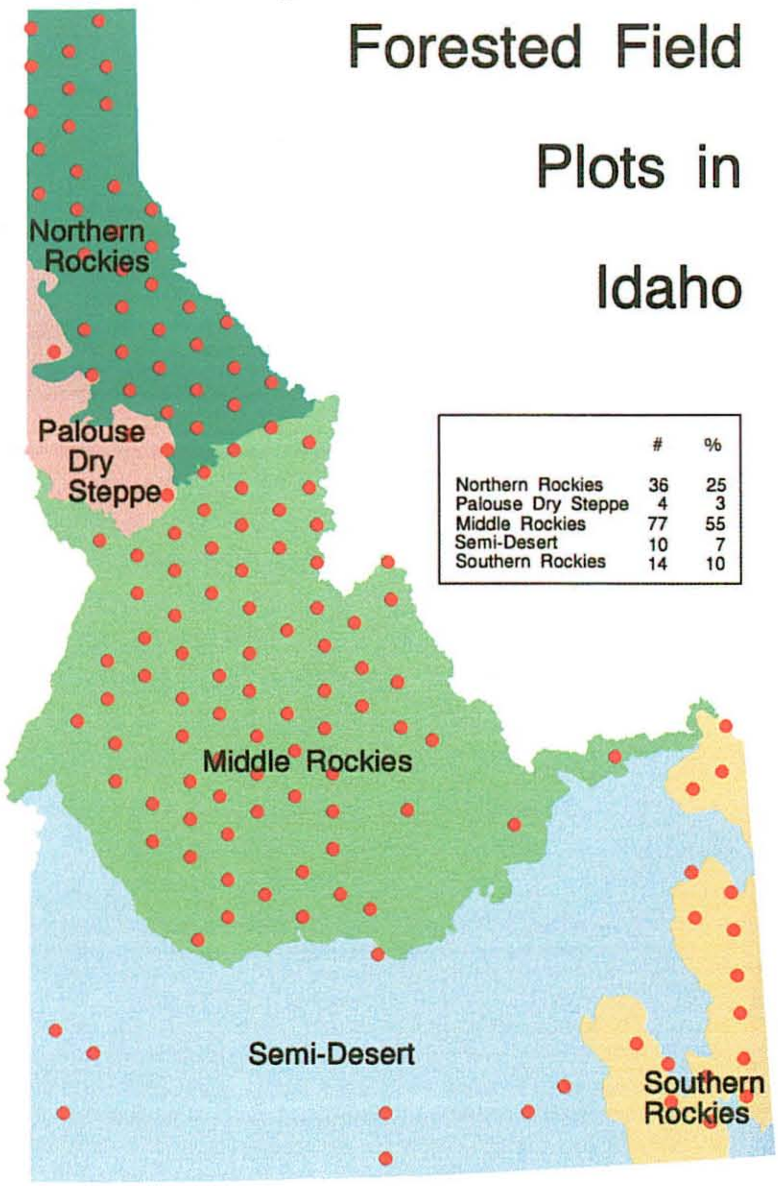
Within Idaho, the province is defined chiefly by the granitic intrusions that form the Idaho Batholith. The southern and eastern fringe of the Middle Rockies are basin and range formations more similar to those of central Nevada.

Elevations generally range from 3000 to 9000 feet, although the highest peak in the state is found in the Lost River Range, topping 12,000 feet.

Precipitation is mostly in the form of snowfall, with valleys receiving less than 20 inches annually, while the higher elevations receive about 30 inches.

In contrast to the Northern Rockies, the aridity and evaporation rates of the Middle Rockies often sharply define forest and nonforest tracts. Both upper and lower treelines are common. Low and middle elevation forests on south and west facing slopes are often dominated by sagebrush semidesert conditions, while the opposite aspects consist of Douglas fir, grand fir, and ponderosa pine, depending on locale within the province.

Figure 5. Ecoregions of Idaho



Lodgepole pine is common throughout the region on a variety of aspects. At higher elevations Engelmann spruce and subalpine fir are the most common species. In the northernmost reaches of the province, where rainfall and evaporation rates more closely resemble the Northern Rockies province, nonforest lands are less common.

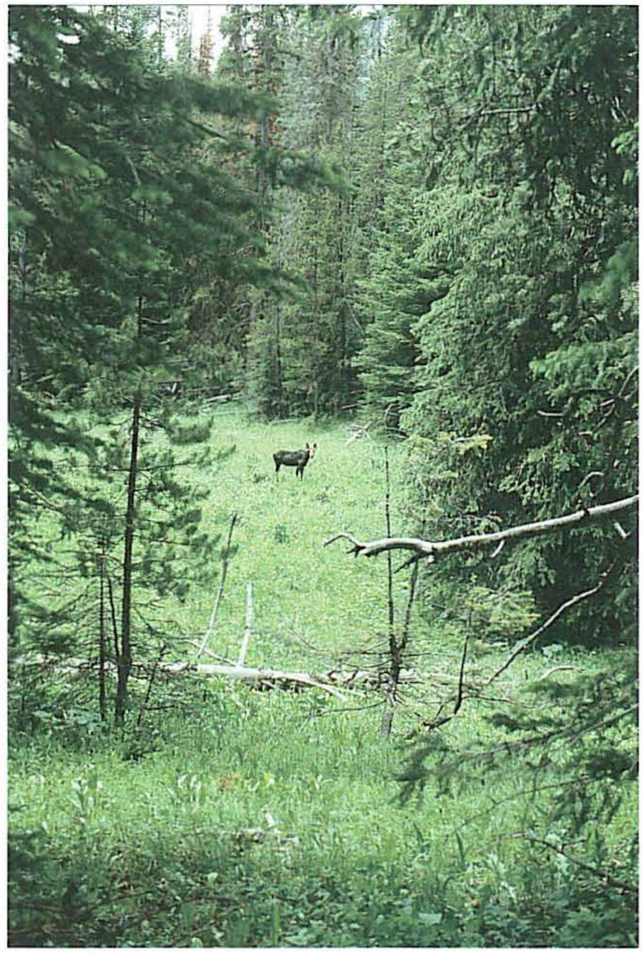
· Southern Rockies Province: *Southern Rocky Mountain Steppe - Open Woodland - Coniferous Forest - Alpine Meadow Province*

The Southern Rockies are confined to southeastern Idaho and the Yellowstone Plateau. Elevations range from 4,000 to just under 10,000 feet. Intermontane valleys are composed mostly of developed farmlands or sagebrush steppe.

The climate of the Southern Rockies is best described as highly variable, depending on local elevation and aspect. In general, valleys are warmer and drier, with annual precipitation of 15-25 inches per year. Higher mountain ranges are much cooler and precipitation is 40 inches or more annually.

Much of the moisture comes in the form of winter snow. The flora of this region is also highly variable. Because of constant changes in elevation and aspect—and subsequently soil types, rainfall, and evaporation rates—mountain vegetation resembles a large-scale mosaic of conifers, hardwoods, and shrub/grasslands.

Southern Rockies forests are often depicted with spruce and fir dominating the highest forested elevations, lodgepole pine and aspen at mid-elevations, and Douglas-fir and juniper defining the lowest forested zone. Although this holds true generally, there are often exceptions based largely on aspect and a sprinkling of less common forest types, such as limber pine or bigtooth maple.



· Intermountain Province: *Semidesert Province*

The Intermountain Semidesert Province covers most of the southern one-third of the state. The area is dominated by the Snake River plain, although smaller mountain ranges abound. Lower valleys are between 2000 and 4000 feet elevation, while scattered mountain ranges average between 7000 and 9000 feet.

Unlike the Rocky Mountain Province, there is less variation in temperature or precipitation across the Semidesert Province. Annual precipitation is about 15 inches per year and is fairly evenly distributed through the seasons, except for summer when very little rain falls. The vegetation is composed primarily of sagebrush, rabbitbrush, and bunch grasses. Riparian zones are lined with cottonwoods, shrub-form willows, and sedges.

Forested areas are rather sparse, being composed primarily of isolated mountain ranges of Douglas-fir, aspen, and juniper. In the southwest Owyhee Desert, there are large forests of western juniper with occasional stands of Douglas-fir or ponderosa pine.

Changing Conditions

Change is fundamental to all ecosystems. Change can occur suddenly or over such a long period that no change is apparent in the short term.

The process of vegetation change is called forest succession. "Disturbances," notably fire, insects, disease, climate and human activity, influence the direction and rate of change (Rogers 1996). Without disturbance, forests change, but at a different rate and direction. (Covington and others 1994.)

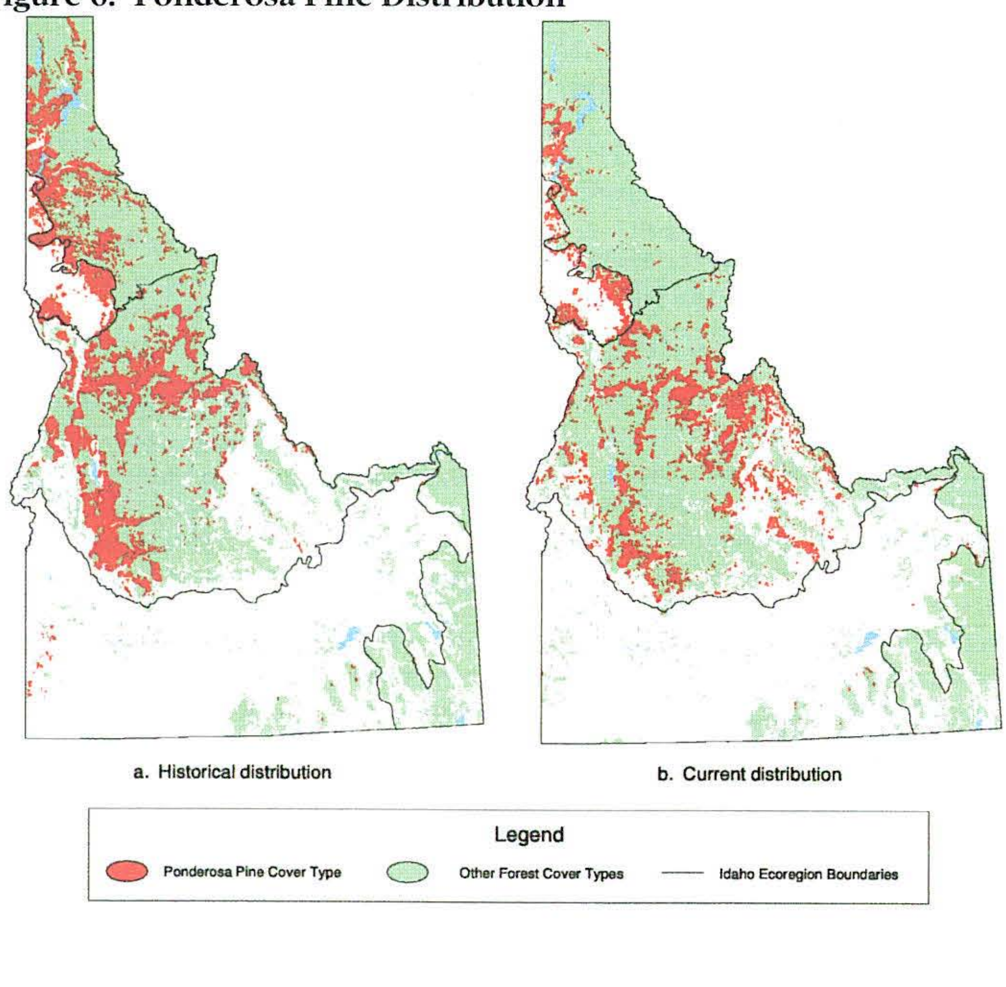
Prior to European settlement, fire was the primary means of vegetative change, ignited by either American Indians or lightning. Settlement brought new agents of modification. Timber harvesting and fire suppression were meant to provide income and products or to protect people and property. However, other changes were unintentional, such as the introduction of damaging diseases, insects or vegetation. Some unanticipated side effects of intentional activities also have proved to be a negative, such as overly dense forest resulting from wildfire suppression.

Fortunately vast areas of Idaho still exhibit intact forests of native tree species. While all native tree species are present, in some areas proportions have changed substantially. Still these forests provide habitat for a large number of native birds and other animals. These forests also are highly valued for their recreational opportunities, wildness, and commodities they produce.

Ponderosa Pine

Historically, ponderosa pine forests predominated on warm-to-hot, dry sites at the lower elevations along the east slope of the mountains and in major river valleys in the Northern Rockies, Middle Rockies and Palouse

Figure 6. Ponderosa Pine Distribution



grassy, semi-arid plains (steppe) Ecoregions (Figure 6a). Mature ponderosa pine forests were commonly quite open, a condition that was maintained by intermittent low intensity fires averaging every 5 to 25 years (Crane and Fischer, 1986). These surface fires consumed the needle duff and killed most understory trees. Bark beetles killed individual or small groups of aging or stressed trees, which were eventually replaced by regeneration that had survived the fires.

Ponderosa pine is now less common, having been replaced by denser forests of Douglas-fir or grand fir (Figure 6b). Acreage decreased by 44 percent for Idaho as a whole during the period 1952-87 (Brown and Chojnacky 1996). The change is a result of fire suppression and timber harvesting. Without fire, the more shade-tolerant Douglas-fir and grand fir become established and outcompete the ponderosa pine.

Early harvesting of ponderosa pine accelerated the shift in composition toward Douglas-fir and grand fir. The net result has been a change from predominantly semi-open, mature ponderosa pine forests to dense, younger forests, many of which are multi-storied, shade tolerant species more susceptible to fire and disease.

The changes in forest composition and structure have favored a number of native insects and diseases. Douglas-fir dwarf mistletoe builds up to high levels in dense, slow-growing stands and when infected overstories provide an infection source for understory trees.

Bark beetles kill ponderosa pine at increased rates in the dense stands, especially during periods of drought. Defoliating insect outbreaks periodically occur, with most significant effects occurring in multi-storied Douglas-fir and grand fir stands.

Altered forest structure and composition have also increased risks from wildfire. Fire suppression has permitted greatly increased ground fuels, with the multi-storied condition creating a "fuel ladder." Fires often burn hotter and more extensively than they did in the past, creating conditions where many fires can no longer be contained.

More than half a million acres burned between 1989 and 1994 on the Boise National Forest. In the past, fires in this forest type were primarily low to moderate intensity, and most of the large ponderosa pine survived. A relatively small amount of the forest burned severe enough to kill all the trees.

Unlike the low-moderate intensity fires of the past, some wildfires now are lethal across large areas (Figure 7) with the potential for damaging the productivity of soils and increasing erodibility through the consumption of organic matter and high temperatures especially when coarse textured soils are involved. (Wells and other 1979).

Figure 7. Severe Fire, Boise N.F.

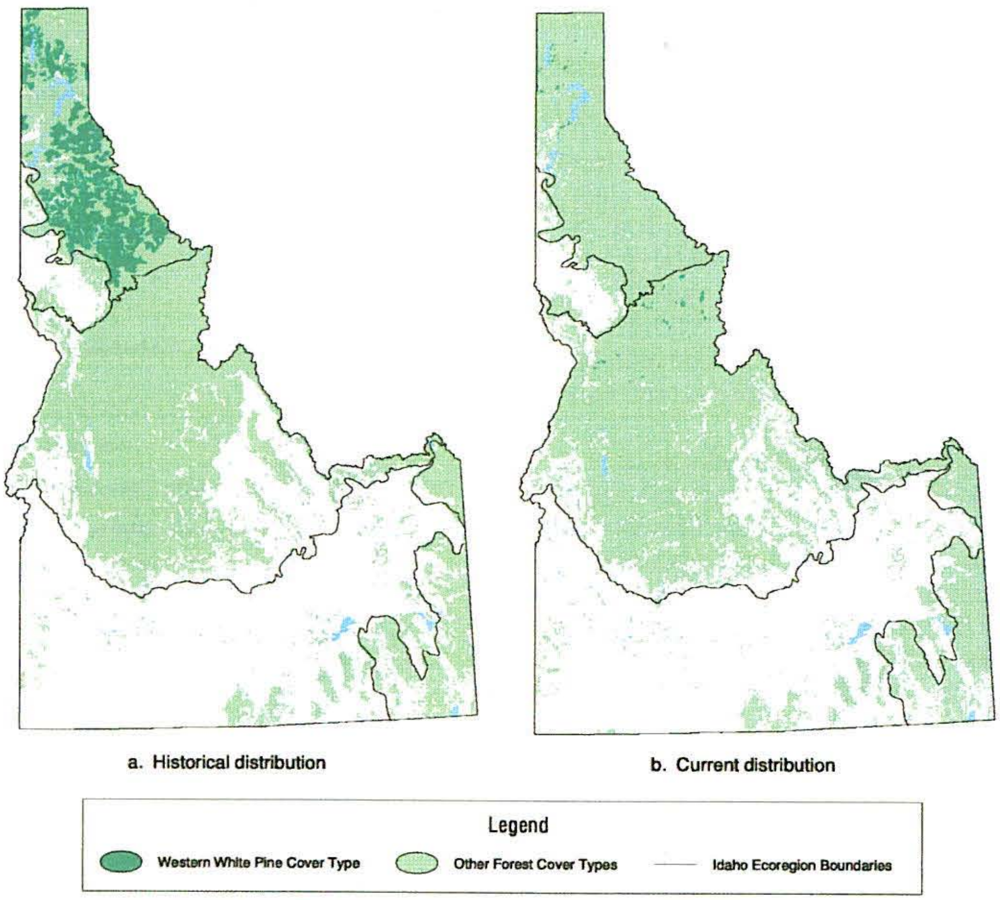
Western White Pine

In Idaho, western white pine occurs almost exclusively in the Northern Rockies Ecoregion (Figure 8). Until about 50 years ago, it was the most abundant forest type in that region.

Prior to European settlement, the landscape pattern consisted of large mosiacs of many thousands of acres, major portions of which were of a similar age class, a legacy of mixed-severity and large stand-replacement fires. White pine forests of 200 or more years of age were common, but so were newly regenerated small trees and shrubs resulting from recent burns, as were forests of an intermediate age. Data from the Coeur d'Alene Basin indicates stand replacement fires occurred at a given location every 150 to 250 years on the average (Zack and Morgan draft). Mixed severity fires that killed only part of the stand occurred at about 60 to 85 year intervals. After a long absence of fire, western redcedar, western hemlock, or grand fir—species most tolerant of shade—would eventually dominate a site. Prior to fire suppression, these species rarely predominated except on the wettest sites because of their susceptibility to fire.

Today, the amount of western white pine is 93 percent less than 40 years ago, as displayed in figures 8a and 8b (Brown and Chojnacky 1996).

Figure 8. Western White Pine Distribution



The causes of change include outbreaks of the mountain pine beetle, fire suppression and harvesting (Byler et al. 1994, Harvey et al. 1995).

The primary agent of change, however, is the white pine blister rust. The rust, a disease of white pines, did not formerly occur in North America until accidentally introduced into Vancouver Island, British Columbia in about 1910. By the 1940s, the disease was epidemic in Idaho. Today, a combination of blister rust, mountain pine beetle and harvesting has nearly eliminated mature western white pine stands. Remaining large western white pines now exist mostly as scattered individuals. The rust continues to kill most trees that regenerate naturally, and rust and bark beetles continue to kill remaining large trees.

Rust resistant western white pine strains have been bred from wild white pines, which have shown some level of genetic resistance. Rust resistant seedlings have been planted since the mid-1970s, but the amount represents only a small part of the area previously occupied.

Natural regeneration is also encouraged where possible, mainly for gene conservation. Even though most trees will die from the rust, some will live and may carry genes for rust resistance and other traits that are important to the eventual restoration of the species.

The numbers of plantings have not been adequate to offset the rate of continuing loss of larger trees and the non-resistant natural regeneration. Statewide inventory data show that mortalility is greater than growth for the species (Brown and Chojnacky 1996). On federal lands, planting has decreased in recent years due to the decreased amount of regeneration harvesting.

The decrease in western white pine is significant both economically and ecologically. Economically, western white pine is the most valuable of timber species, and potentially can produce greater biomass than its associates, especially at ages over 100 years.

In terms of the ecology of the species, western white pine achieved large size and 200 years or more of age. Thus, it was the main component of many old growth forests in the Northern Rockies Province. Western white pine is resistant to root rots that significantly affect many other tree species in this forest type.

Western Redcedar-Western Hemlock

Western redcedar and western hemlock occur on very moist sites in the Northern Rockies. Western red cedar has a similar range to the historical range of western white pine. Western hemlock occurs on wetter, more northerly sites and has an even more restricted range. Both are very susceptible to injury and death from fire.

The two species have increased greatly during past decades, as shown in figure 9. Wildfire suppression, the blister rust, and selective harvest of white pine and larch have favored conversion to cedar and hemlock.

Performance of western redcedar and western hemlock on dryer sites is not fully understood because the stands are still relatively young. Of concern is their drought susceptibility. Growth is generally less than species they replaced, especially when affected by root disease. And they are quite susceptible to stem decays, which significantly affects their value for forest products.

Western Larch

Western larch occurs in the Northern Rockies Ecoregion and in the northeast portion of the Middle Rockies Ecoregion. It is very intolerant of shade but highly tolerant of fire. Historically it occurred as the predominant species on sites where mixed severity fires killed the thinner barked species.

The amount of western larch cover type has decreased by 72 percent since the mid 1950s (Brown and Chojnacky 1996). It has been replaced largely by Douglas-fir and grand fir, species that are more susceptible to fire, drought, insects and disease.

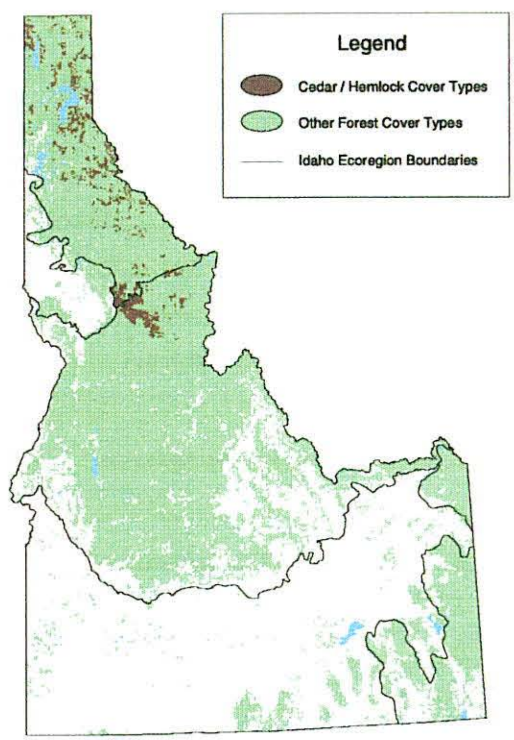
Western larch has few serious insects and diseases, and the most significant impacts have come from management practices that favored shade tolerant species (Carlson et al 1995). These include selectively logging of the more valuable big larch; lack of regeneration harvesting or fire; and a lack of thinning, either mechanical or fire induced.

Douglas-fir

Douglas-fir is currently the most prevalent forest type in Idaho. It can be found in extensive pure stands, either even- or uneven-aged, or in mixture with a wide range of other species.

Statewide, the amount of Douglas-fir cover type has increased modestly over past decades (Brown and Chojnacky 1996). Rather large increases have occurred in some areas, however, such as in the Northern and parts of the central Rockies where it has replaced western larch and western white pine on many sites. It also has become the predominant species in locations throughout the state where ponderosa pine has decreased.

Figure 9. Cedar / Hemlock Distribution



Current distribution

Successful fire control during the 20th century has increased stand densities in some warm, dry Douglas-fir types and created fuel ladders where large intense fires may result (Crane and Fischer 1986). In addition, successful fire control has increased the area occupied by Douglas-fir by allowing it to invade dry sites that were formerly grasslands maintained by fire.

These changes in forest composition have favored a number of native insects and diseases, defoliating insects, dwarf mistletoes and root rots (Byler and Zimmer-Grove 1990). These are discussed further in the "issues" section of the report.

Lodgepole Pine

Lodgepole pine occupies 2.3 million acres in Idaho and grows under a wide range of conditions. It can be found in all the provinces except the Intermountain and Great Plains. It occurs in pure or mixed species stands. The amount of lodgepole pine cover type in Idaho has decreased slightly during recent decades.

Fire, mountain pine beetle, and dwarf mistletoe are three important disturbance agents which greatly affect growth and development of lodgepole pine forests (Gara and others 1984). The age of these forests on the whole are greater now than typically in the past, which has provided abundant food for mountain pine beetles.

Fire is a principal factor in the establishment and structure of most lodgepole pine forests. Historically, the frequency of fires varied every 60 to 500 years and their severity resulted in a diverse mosaic of age classes and species mixtures in Idaho's lodgepole pine forest types (Romme 1982).

In the Northern Rockies province, severe fires typically have created large expanses of even-aged, pure or mixed species stands of lodgepole pine. In the Southern Rockies Province, low-intensity surface fires often have maintained multi-aged stands in which climax species were unable to develop (Lotan and Perry 1983). The Middle Rockies have a good representation of both conditions. Fire suppression efforts, however, have reduced the diversity of age classes and forest structure.

Mountain pine beetle has played and continues to play an important role in the cycle of fire and reinvasion that has maintained lodgepole pine forests. By periodically killing trees and creating large amounts of fuel, the mountain pine beetle enhances the probability that a lodgepole pine stand will be destroyed by fire and will reoccupy the site before it is succeeded by other species. For example, between 1975 and 1981, millions of lodgepole pine were killed by mountain pine beetle in Idaho. After 20 years, most of those dead trees have fallen and created a "jackstraw" of woody material that represents a huge amount of fuel and a very high risk of fire.

There have been extensive logging activities in some parts of the state to salvage the dead trees and to harvest stands of lodgepole before they were attacked by the mountain pine beetle. This has created some areas of younger lodgepole forests, although the pattern of the forest patches is much different from what wildfires created in the past.

The occurrence and spread of dwarf mistletoe in lodgepole pine was limited in the past in some areas by large stand replacement fires. Fire suppression has allowed the amount of dwarf mistletoe in lodgepole pine to increase. In southern Idaho, an estimated 64 percent of all lodgepole pine stands contain some level of dwarf mistletoe infection. (Hoffman and Hobbs 1979).

Aspen Forest Types

Aspen stands are unique from previously discussed shade-intolerant species in two important ways: (1) Aspen are a short-lived seral species, typically only surviving from 60-120 years. (2) They are really stems originating from large underground root systems. All of the "trees" connecting to the same root system are genetic clones of one another. These large root systems, often covering several acres, reproduce by sending up thousands of "seedlings," technically suckers, after the aspen overstory is disturbed.

Lack of fire in aspen communities has allowed conifer species to establish and eventually dominate these areas. Aging aspen is subject to damage from a variety of stem and other diseases. FHM data indicate that such damage is common. Only 38 percent of the trees examined were free of damage; whereas more than 80 percent of conifers were undamaged. (Appendix A)

Aspen forests appear to be on the decline throughout the Interior West and in portions of the Inland Northwest (Bartos and Mitchell 1998; Brown 1995). In Idaho, this phenomenon appears to be most pronounced in the Intermountain, Middle and Southern Rockies Ecoregions. A recent inventory of tree cover on the Targhee National Forest indicated about a 90 percent decrease in aspen since the beginning of this century (USDA Forest Service 1995). Succession to other species from the lack of fire was the primary cause of aspen decrease (Figure 10). Secondarily, grazing by large numbers of cows or big-game prevents successful regeneration.

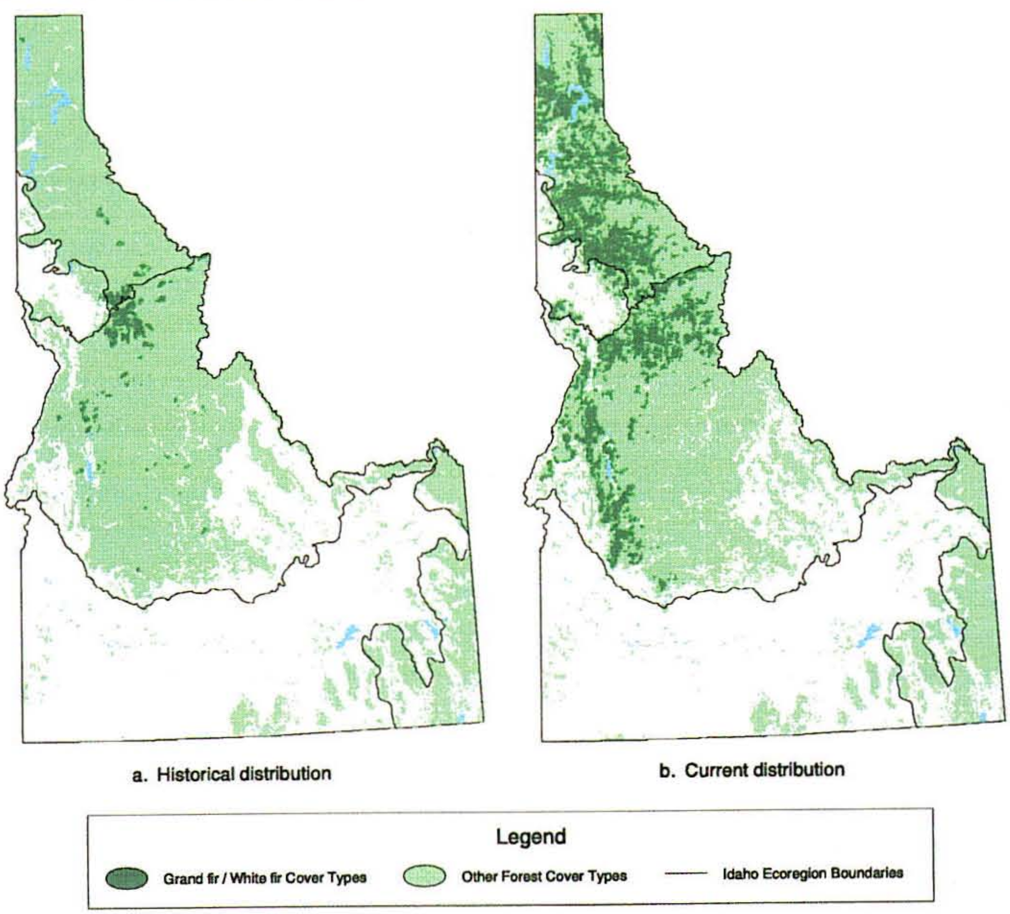
Grand Fir

Figure 10. Conifers taking over aspen.

Grand fir occurs throughout the Northern Rockies and in the northern and western parts of the Middle Rockies (Figure 11). It accounts for 2.2 million acres of forested land in Idaho, a significant increase over the past several decades (Brown and Chojnacky 1996). Brown and Chojnacky (1996) found that the "spruce-fir" class increased by 177 percent (Figure 11). Data from the Idaho Panhandle National Forests in the Northern Rockies, suggest a 300 percent increase (Zack 1997).

Causes of the increase include fire suppression, white pine blister rust, and selective harvesting practices that decreased the historically abundant pines and larch and allowed the shade-tolerant grand fir to increase. On drier grand fir sites, frequent surface fires historically maintained open stands of fire-tolerant ponderosa pine with some Douglas-fir. On cooler and wetter sites where fires were less frequent, open stands of western white pine, Douglas-fir, western larch and sometimes lodgepole pine occurred. Grand fir now dominates on many of these sites.

Figure 11. Grand Fir Distribution



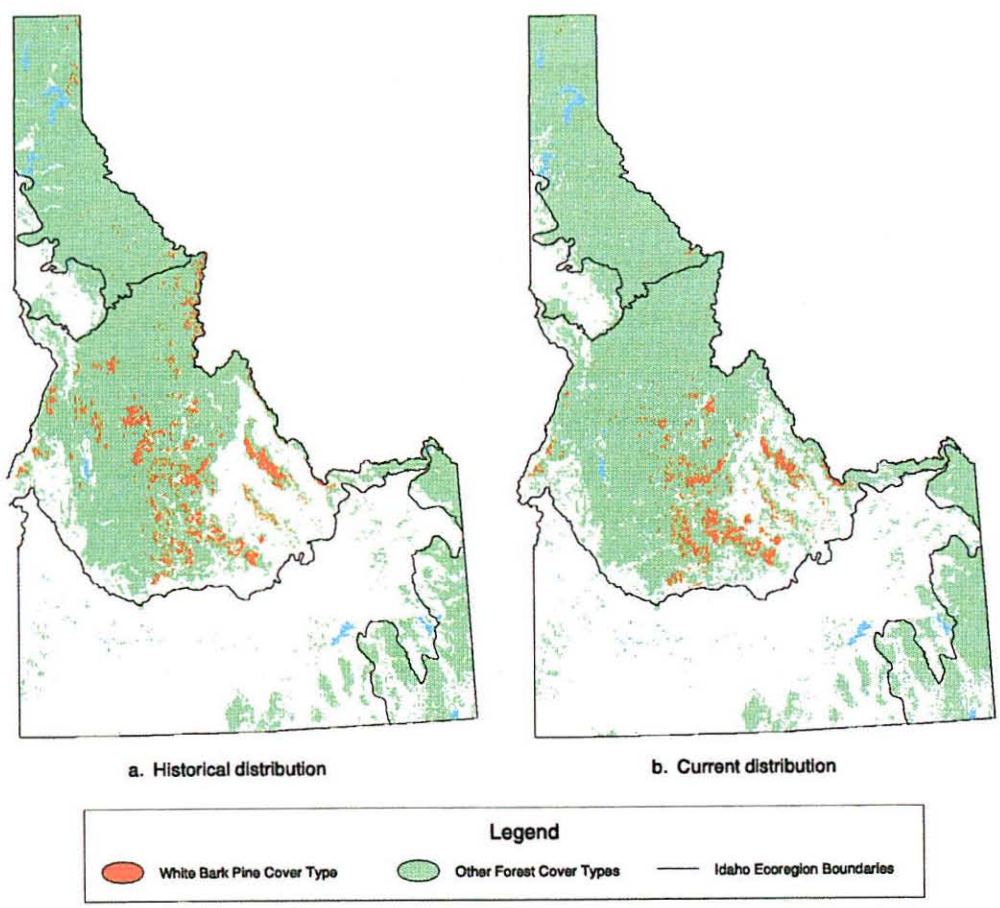
Grand fir is highly susceptible to drought, wildfire, and several damaging insects and diseases. Extensive mortality periodically occurs from fir engraver beetle, particularly following drought, or when it is infected with root rot. It is also impacted by outbreaks of defoliating insects. In the Northern Rockies and northeastern Middle Rockies, it is highly susceptible to root diseases. And the increase in dense, often multi-storied stands of grand fir also creates a growing risk of large severe fires.

Whitebark Pine

Whitebark pine occurs in high-elevation, cold conditions in both the northern and southern parts of the state (Figure 12). Ecologically, whitebark pine is important: its seeds are a valued wildlife food for birds, squirrels, black and grizzly bears. Whitebark pine also is important in reducing avalanche potential and soil erosion (Frey 1994). It is the only tree species that will grow in some locations.

Whitebark pine, like western white pine, is a five-needle, white pine that is very susceptible to the introduced white pine blister rust disease (Hoff and Hagle 1990). In the Northern province, the impact of the rust has been very significant, but variable in the amount of mortality in the Middle and Southern Rockies. The rust is still expanding in the south, however, and significant future damage is expected, although the rate of infection is slower because the environment for the spread of the rust is not as conducive as in the north. Stands have also declined as a result of fire suppression efforts and mountain pine beetle attacks (Bartos and Gibson, 1990), which has allowed subalpine fir and Engelmann spruce to increase on many sites with the whitebark pine. These species can continue to grow in the shade of other trees, but the whitebark pine does not tolerate as much shade and over time is replaced (Arno 1986, Kendall and Arno 1990).

Figure 12. White Bark Pine Distribution



Forest Health Issues

Forest health issues are rooted both in their ecological as well as social aspects. A forest is a dynamic system, continually changing in response to disturbances. Some disturbances help maintain native species and historic conditions. Others threaten them. Thus, there are limits to which a forest can recover from disturbances, especially exotic ones.

Ecological integrity is defined as the forest's ability to renew itself, or the ability to withstand disturbances and recover through time and across the landscape. If the forest is to have the potential to meet social needs, including wildlife habitat, clean water and products such as wood and recreation opportunities, then the integrity of the ecosystem must be retained.

The following sections address seven issues facing Idaho's people and their forests:

- Introductions of non-native species
- Watershed health
- Homes in and adjacent to wildlands— the "wildland/development interface"
- Harvest rates and sustainability
- The role of native insects and disease
- The role of wildfire and fire management
- Biological diversity of Idaho's forests

EXOTIC INTRODUCTIONS

The introduction of foreign plants, animals, and microorganisms is one of the most disruptive influences on ecosystems. Sometimes a non-native species will find conditions highly favorable in its new location. With natural enemies left behind, populations expand unchecked until the species becomes a pest.

The result can be that non-native species eliminate native plants or animals from an ecosystem, greatly altering how the ecosystem functions. This is happening in Idaho, where a number of invaders have damaged the state's ecology and economy.

White Pine Blister Rust

White pine blister rust was accidentally introduced into western North America about 1910 on infected seedlings grown in France and planted near Vancouver, British Columbia.

The disease was first discovered in Idaho in 1927, and then spread rapidly throughout the western white and whitebark pine forests of the northern Rocky Mountain Region. Spread to whitebark pine and limber pine in the central and southern Rockies has been slower, but the fungus is now intensifying in those areas also (Smith 1998).

Blister rust has had a devastating effect on western white pine and whitebark pine forests in the north. Widespread tree killing was apparent by the 1940s, and now, after 50 years, the forests of western white pine are nearly gone. Smaller trees were and continue to be killed by the rust directly; larger trees were killed by one or more of the following: the rust, mountain pine beetle and/or logging.

Among the dead and dying western white pines were a small proportion that were uninfected. Research showed that these trees were genetically resistant to the disease (Bingham 1983). That resistance became the basis for a tree breeding program. Rust resistant trees for outplanting became available in the mid-1970s, and a small portion of white pine's former range has been replanted.

Implications

In the long term, success in restoring white pines will likely depend on both continued integrated management (Hagle et al 1989) and gene conservation. An effective strategy might include the following parts: (1) a commitment to reforestation, mainly by planting and tending rust resistant seedlings but also natural regeneration. This will require opening up the forest through burning, harvesting or a combination of the two; (2) species and gene conservation, through the maintenance of wild stock that may have resistance and enhancing opportunities for natural regeneration and natural selection; (3) continued research, tree improvement, and monitoring to assure needed information and technology is available to future practitioners so they can adapt and improve upon today's efforts.

Choosing not to restore the white pines will mean the continued expansion of other forest types, such as grand fir, hemlock-cedar, spruce-fir and Douglas-fir, and their associated problems of insect, disease and fire susceptibility.

Balsam Woolly Adelgid

The balsam woolly adelgid, an aphid-like insect of European origin, was discovered in northern Idaho in 1983 at one urban site in Coeur d'Alene, Kootenai County, and five forested sites east of Moscow, Latah County (Livingston and Dewey 1983).

Its Idaho hosts are primarily subalpine fir, and secondarily, grand fir. Since the initial discoveries, the insect has spread to where it now covers many drainages of Clearwater, Idaho, Nez Perce, Lewis, Latah, Benewah and Shoshone counties.

The insect has killed thousands of subalpine fir, especially in frost pocket-drainage bottoms. In these sites we found extensive mortality within six years of the initial infestation.

The insect has also been found infesting and killing subalpine fir in a few high elevation sites of Clearwater County. Grand fir has been infested as well, but there has been relatively little mortality of this host species to date.

Implications

In some drainages the tree mortality caused by the balsam wooly adelgid is affecting riparian areas. At those sites where the subalpine fir previously provided significant shade, that shade is now gone.

The lack of cover could lead to changes in summer and winter water temperatures, long-term woody debris recruitment, and to fish habitat in general.

High elevation stands of subalpine fir are also being affected. The loss of trees in these sites may have detrimental effects on wildlife, watershed and recreation resources.

Non-Native Invasive Plants

Non-native invasive plants currently infest over 4.7 million acres of land in Idaho, including all land-use classifications and ownerships (personal communication with Loall Vance, Idaho Department of Agriculture). Several of these plant species have particularly onerous characteristics, making them ecological and economic pests and, as such, have been designated as "noxious" by state law.

Such plants are moving into forest areas via windblown seeds, domestic and wild animals and on vehicles and other machinery. They include, but are not limited to, spotted knapweed, rush skeletonweed, leafy spurge, Canada thistle, cheatgrass, meadow and orange hawkweeds and yellow starthistle.

Invasive "exotics" are very effective at colonizing disturbed areas where overgrazing, timber harvest, road construction, landslides, or fires have occurred. Some of the species, like the hawkweeds, do not need disturbance to invade a plant community. Their introduction, establishment and spread is causing rapid changes in the succession, species diversity and function of many ecosystems.

Disruption in ecosystems by invasive exotic weeds is considered unhealthy, as these plants displace native plants. Changes in plant community composition, diversity and structure can adversely affect the quantity and quality of forage for livestock and game animals, erosion of soil, sediment in streams, wildlife habitat, tree regeneration, recreation sites and rights-of-way (Duncan 1997, Rice and others 1997).

Implications

Non-native invasive plant introductions and spread are occurring more rapidly than our ability to assess and address them. Weeds do not respect ownership boundaries; therefore to be effective, cooperation between neighbors is needed.

Work is being done in some areas where counties, federal and state agencies and private individuals have formed weed management areas to combine and coordinate efforts within the area. Work by these groups using integrated pest management practices, such as prevention, early detection and suppression of new invaders, is critical. Also key to success for all landowners is the use of long-term strategies on biocontrol for established weeds.

WATERSHED HEALTH

Water originating in forested areas throughout Idaho is valued for many reasons, from its use for domestic needs to providing habitat for anadromous fish species. The forested lands adjacent to streams and rivers serve to collect and purify the water, funneling it through a network of stream channels into the river systems.

The ability of the forests to collect and purify water is affected by the condition of the forest and the occurrence of disturbances that change the structure, composition and pattern of forest vegetation.

Because of its widespread implications, water quality has become a major forest management issue. In some watersheds riparian areas and stream channels have been negatively impacted directly by logging, by fires, by road building, by dams and by mining. Indirectly, these same events occurring on upland areas may also affect water quality and streamside conditions.

Some relationships between water quality and condition of the upland vegetation are poorly quantified. However, we know changes in the amount, structure, composition of vegetation, both live and dead, within a watershed may affect several different aspects of water quality.

Some aspects of water quality affected by vegetation include the amount of water flowing out of the watershed, the retention of snowpack, the amount of sediment carried by the water, the water's temperature and nutrient content. Variation in these characteristics over time and across a watershed is normal and desirable for the proper function of the system. The variation is a function of the amount of plant cover alive and dead in the form of litter, duff and woody debris, successional stage, pattern and structure of the vegetation across the watershed. Changes in the vegetative condition may be the result of fire, harvest, insect or disease activities, developments including roads, mining or subdivisions. Concerns are raised when the variation of these attributes exceeds the normal variation.

It is beyond the scope of this report to assess the health of Idaho's watersheds but it is important to recognize the links between watershed health and forest health.

Implications

The long-term health of watersheds and the health of the vegetation in a watershed are inextricably linked, they are parts of a whole ecosystem. An ecosystem that is dynamic with or without human intervention. Therefore management decisions need to weigh short-term trade-offs with long-term benefits. Ignoring watershed health in favor of vegetation health or ignoring vegetation health in favor of watershed health are paths doomed to failure over time. Management actions carefully designed, executed and monitored, so we continue to learn from our experiences, can facilitate the attainment of both goals in the long run.

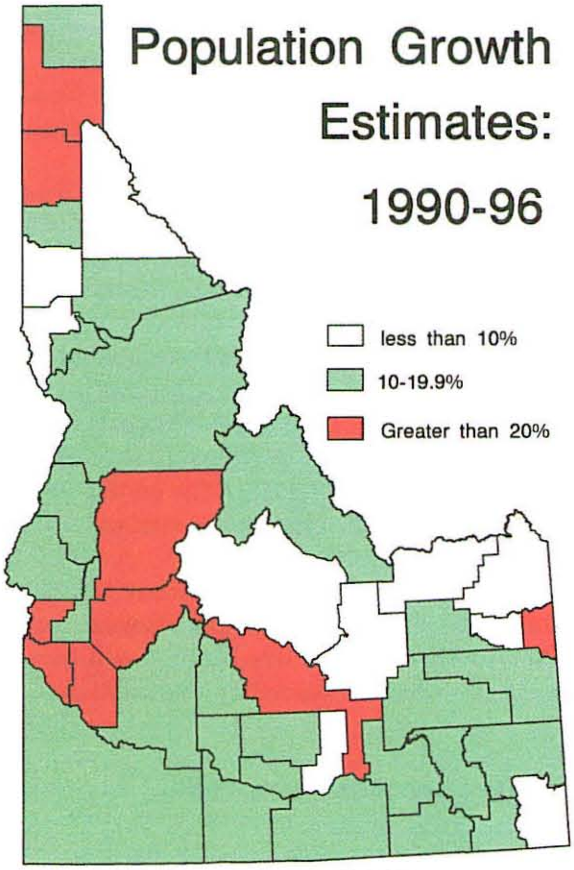
Watersheds are nested, from small to very large, and consideration of activities across these scales can facilitate effective scheduling of management treatments, such as prescribed burning, restoring roads no longer needed, timber harvests, stream improvement projects or "resting" a watershed. Communication and cooperation across ownership boundaries within a watershed can enhance achievement of sustainable management for all owners.

WILDLAND INTERFACE DEVELOPMENT

While natural disturbance events, like fires and insect outbreaks, are common and even healthy for many forests, they present more difficult situations in developed areas (Rogers 1996). If forests deteriorate, some people are affected by the aesthetic loss of forest cover and for other reasons and values for which they move to a wildland location. Another issue is the fire hazard and threat to life and personal property presented by abundant dead or dying trees. While urban areas throughout the Interior West have experienced population booms in the past decade, so have rural areas. Many people continue to seek rural locations with nearby recreational opportunities. While some counties are growing faster than others in Idaho, the state as a whole has been growing at an estimated rate of 18 percent per year since 1990.

Only a few counties are experiencing low growth rates (Figure 13). Much of the development that supports this influx of people is in, or adjacent to, forested lands. While some of that development is taking place near Idaho's larger population centers, there is also a substantial amount of new dispersed housing in rural counties.

Figure 13.



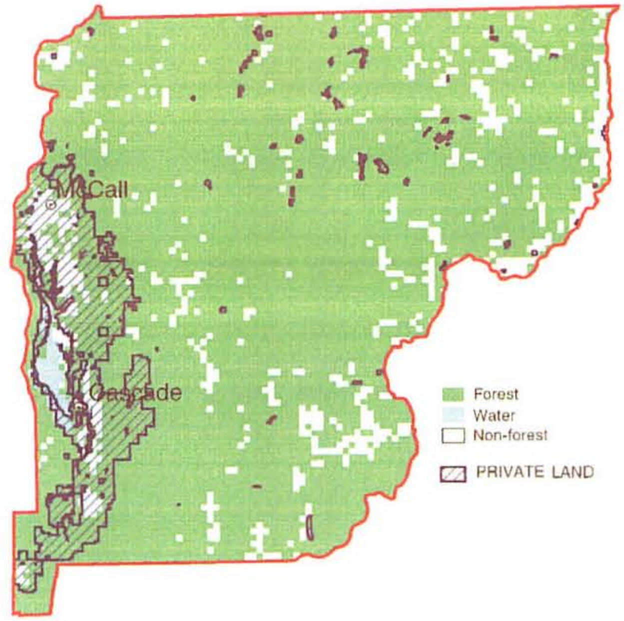
Source: Idaho Bureau of Census, 3/20, 1997

Valley County, in the central portion of the state, is a good example of the growth phenomenon (Figure 14). The county is estimated to be expanding at a rate of about 31 percent. Much of the land within the county's borders is both forested and government owned. About 20 percent of the land base is in private ownership and, therefore, potentially available for residential development. Nearly all of that development is in close proximity to the surrounding forest lands.

The problem in terms of fire management is obvious. The probability of human-ignited fire is greater where there are more people, and there is an ever-increasing population in the wildland interface. More fire starts in conjunction with dense forests and hot or windy weather conditions, increases the possibility of fires capable of destroying homes and putting human lives at risk.

Figure 14.

VALLEY COUNTY FORESTS
AND PRIVATE LANDS



Implications

The issue of the wildland interface spurs numerous questions. How much of forest lands should society develop for residential purposes? If houses are built or already present, who will take the responsibility of managing surrounding forests to protect human interests? How can individual homeowners reduce the risk to their property and lives?

Where human development is adjacent to forested wildlands, more intensive management practices may be necessary to minimize the risk of serious loss of life (Fuller 1991). Such practices include forest thinning and creating nonforested buffers. For instance, removal of "hazard trees," or trees that are rotten or partially dead near human structures, is good "preventive medicine" against future injury or property damage.

Forest health along the urban/rural wildland interface is more than just a problem for people. When people move into forested areas, habitat is diminished for some animals. Wild animals that remain are often in conflict with humans. Examples include mountain lions preying on domestic animals or deer browsing on residential shrubbery.

FOREST GROWTH

Data shows the total inventory volume of growing stock on Idaho's timberland totals 39.6 billion cubic feet, an increase of 12 percent between 1952 and 1987. Average net annual growth was 816 million cubic feet. Of that growing stock, 76 percent is on National Forest System (NFS) lands.

The volumes of western white pine, western larch and ponderosa pine have decreased. Ponderosa pine and western white pine, historically the two most important timber species in the state, declined by nearly 4 billion cubic feet between 1952 and 1987 (O'Laughlin, et al. 1993). Ponderosa pine decreased by 40 percent and western white pine by 60 percent.

Douglas-fir increased by 15 percent and now composes 31 percent of the total growing stock (Figure 15).

An aggregation of Engelmann spruce, western larch, western red cedar, and western hemlock increased by 30 percent. Although western larch is included among the class experiencing an increase, it most likely decreased since the acreage in larch type decreased.

Net growth can be compared with tree removals to estimate net change. Overall, net growth was nearly three times tree removals, but there were substantial differences by ownership. On NFS lands, the growth was more than four times greater than the removals; whereas on other ownerships it was about one and one-half times greater than removals .

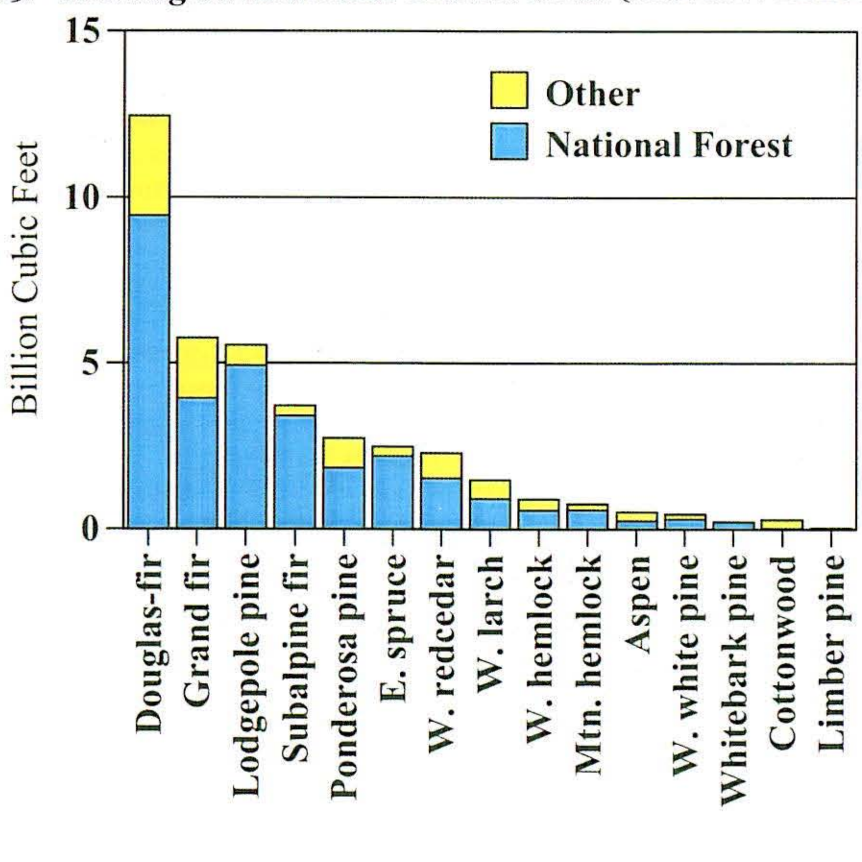
Other factors affecting forest growth include diseases, insects and fire, some more severely at times and locations than others.

Overall, net growth appears positive for most species, with some exceptions. On the Boise and Payette National Forests, mortality from insects, disease and fire exceeded growth for the period 1988-1992.

Mountain pine beetle was the cause of extensive mortality of lodgepole pine on the Targhee, Sawtooth, and Caribou National Forests during the 1970s and 1980s. In northern Idaho, mountain pine beetle in the early part of the century and later in combination with blister rust caused major losses of western white pine.

Root disease is extensive in many locations where white pine and other species were replaced by Douglas-fir and true firs. Timber volumes in infested stands are reduced by about 50 percent.

Figure 15. Growing stock in nonreserved lands (Resource Bulletin. 1988)



INSECTS AND DISEASE

Disease agents (pathogens) and insects affect forests in various ways (Haack and Byler 1993). They are essential to the function of dynamic ecosystems: they serve to thin out some of the trees, recycle nutrients, create habitat and provide food to many wildlife species. They can also negatively affect resource values and ecosystem function.

Thus, their effects may be viewed as beneficial or detrimental, depending on the management objectives of the owner. Key questions involve how insect and pathogen activities affect the things we value, both in the short and long-term.

In this report, we will focus on only a few native pathogens and insects in Idaho, specifically those having the most significant effects on current forest conditions.

From the resource perspective, tree mortality and growth loss can be highly significant. The two affect timber growth and reduce desirable forest cover in recreation areas. They can present hazards to visitors, reduce the ability of forest canopies to intercept snow and prevent excessive runoff, change wildlife habitat and influence various other commodities and amenities.

Fire, insects and disease are regulators of forest change. With wildfire suppression, insects, pathogens and humans have become the major agents of change. In particular, they play enhanced roles in succession, decomposition and nutrient recycling.

Figure 16. Root rot openings.

Insects and pathogens are highly adapted to particular forest conditions, i.e., species composition, age, density, and others. So as forests change in composition and structure, they become more susceptible to some agents and less susceptible to others.

It, therefore, should not be surprising that some insects and pathogens have become less common and some more common as forests change. Given the current susceptibility of some stands, the considerable disease and insect caused changes and resource impacts are expected to continue.

Root Disease

Root diseases are common in the moist Douglas-fir, grand fir and high elevation cool subalpine forests in the Northern Rockies Province. Several pathogens are involved, even in the same stand, so it is usual to consider them as a group. The main hosts are Douglas-fir and true firs. The pines and western larch can be infected, but are not so readily killed (with the exception of annosum root disease in ponderosa pine forests). Root diseases have apparently increased significantly over the past several decades, with the several-fold increase in host abundance. About 2 million acres have been estimated to be significantly affedted by root disease (DeNitto 1985).

Permanent plot data indicates that root diseases commonly kill an average of 2-4 percent of the susceptible trees per year. The cumulative effect of this is the removal of most such trees by 80-100 years (Byler and Hagle, unpublished data). In mixed species stands, disease has a thinning effect by removing susceptible and leaving disease-tolerant species. In stands of susceptible species, the entire stand can be killed.

Root diseases are variable in distribution, but can have major effects in some areas. For example, a root disease assessment in the Coeur d'Alene River Basin in the Northern Rockies indicated that 35 percent of the basin consisted of Douglas fir or grand fir cover types with root disease (Hagle et al. 1994). Of the infested acres, 62 percent were rated as severely affected, meaning more than a 20 percent reduction in canopy had occurred.

Implications

Root diseases may cause extensive mortality in forests comprised of susceptible species. Losses are often underestimated because it occurs in a dispersed pattern in an area infested and over a long period of time. Mortality can be accelerated by activities that thin the forest but retain susceptible species. The most effective treatment in these situations is one that removes most of the trees and reestablishes resistant species, primarily seral species (Figure 16).

Root decay can cause tree failure, which subsequently can have a significant impact on other forest elements, such as wildlife habitat and watershed function. Tree failure can also produce wildfire and safety risk in recreation areas. However, these effects have not been well quantified.

Extensive disease can maintain a watershed in an open or semi-open condition of mostly small trees and shrubs, potentially affecting water yield and peak flow.

Dwarf Mistletoes

Dwarf mistletoes influence the health of coniferous forests because they reduce the vigor of heavily infected trees. The infection eventually kills the affected trees outright or predisposes them to attack by insects and/or other pathogens.

Dwarf mistletoes are important to various wildlife species because birds and other animals nest in witches' brooms or use them for resting and hiding sites (Bull et al. 1997). Therefore, dwarf mistletoes serve to increase species diversity within dwarf mistletoe-infected forests.

Dwarf mistletoes are widespread throughout the forests of Idaho. In southern Idaho, dwarf mistletoes infest 45 percent of the lodgepole pine stands, 33 percent of the Douglas-fir stands and 25 percent of the ponderosa pine stands. In northern Idaho, the most common dwarf mistletoe is larch dwarf mistletoe, and approximately 40 percent of the western larch stands are infested. In total, more than 3 million acres are infested in Idaho (Johnson and Hawksworth 1985).

Dwarf mistletoes are more widespread and common in Idaho forests today than in the past because of fire suppression efforts and selective harvesting practices that left infected overstory trees above those being regenerated. Where ground fires were once frequent, many mistletoe-infected trees were often killed because large, drooping witches' brooms often carried ground fires into the tree crowns.

Implications

Since dwarf mistletoes reduce the vigor of trees and cause death, in forests where this is undesirable i.e., campgrounds, home developments, parks and timber production areas they can be managed to reduce their impact. Methods include pruning or killing the infected trees, and managing the forests for a different species of tree than the ones that are infected.

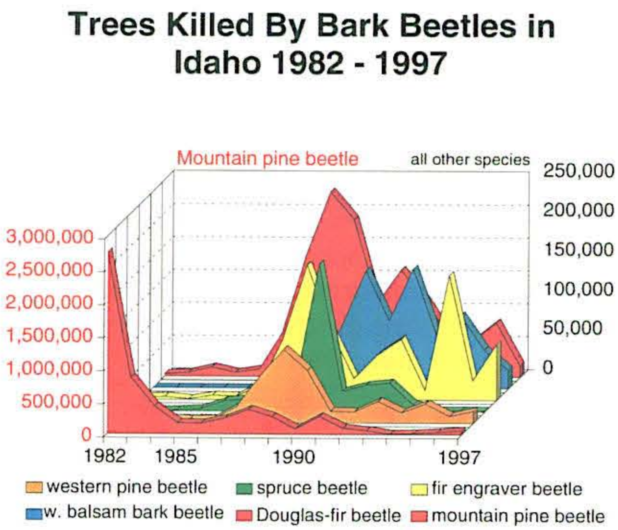
In managing large landscapes where the maintenance of diverse habitat is an objective, it is desirable to have the mistletoe present in a portion of the forest (Taylor 1995). The role of stand replacement fires has been significant in affecting the distribution of mistletoe and needs to be considered when management objectives include the desirability of natural processes, such as wildernesses and national parks (Kipfmueller and Baker, 1998).

Bark Beetles

Bark beetles are considered the most consequential insects in western coniferous forests, where they kill millions of trees annually. Most of this mortality is scattered widely throughout mature forests (Furniss and Carolin 1977). However, when conditions are favorable, bark beetle populations can develop into outbreak proportions and kill large numbers of trees over large landscapes, as currently occuring in northern Idaho with the Douglas-fir bark beetle.

In general, these outbreaks are initiated in trees that are either windthrown or stressed due to overcrowding, drought, inadequate nutrients, injury, advanced age, or climatic change. Other biological agents such as root diseases, foliage diseases, dwarf mistletoes, and defoliating

Figure 17. Bark beetle trends.



insects also cause tree stress and may be associated with bark beetle attack (Steele, et al. 1996).

Beetle mortality contributes snag habitat and offers a source of food to some species of wildlife. In some instances, bark beetles thin the forest.

Mountain pine beetle, Douglas-fir beetle, spruce beetle, western pine beetle, and fir engraver beetle are among the most important mortality agents of mature forest in Idaho. They can significantly change forest structure and composition by reducing the average age, diameter and height of surviving trees. They also lower the density of live trees in the forest. They can affect successional changes in forests, promoting succession in some cases, setting it back in others.

During the past 15 years, several large bark beetle outbreaks have been recorded in southern Idaho (Figure 17). Most of these have occurred over large forested areas where mature host tree species were growing in an overcrowded and susceptible condition. In some areas, beetle outbreaks reduced that susceptibility by killing a high percentage of the host trees. In other areas, the risk of bark beetle outbreaks remains high.

Implications

Among the effects of bark beetles on forest resources are: increased fire hazard due to increases in available fuels; changes in wildlife species composition and distribution through altered habitat conditions to the benefit of some species and the detriment of others; severe outbreaks also may increase water yields because of reduced transpiration from dead and dying trees; reduce timber production and value; increase forage production. These changes can be viewed as desirable or not depending upon the objectives of the landowner.

Where landowner objectives warrant reducing the risk of bark beetle infestation forests can be thinned mechanically or with prescribed fire. In landscapes with more aging, highly susceptible stands than desired, regeneration by harvest or stand replacement fire may be appropriate. Creating a variety of age classes across a landscape reduces the potential for severe outbreaks by having less suitable host available.

Defoliators

Historically, two native insects—western spruce budworm (WSB) and Douglas-fir tussock moth (DFTM)—cause widespread defoliation of Douglas-fir and grand fir forest types in Idaho. They periodically reach epidemic proportions, causing severe defoliation of Douglas-fir, true fir and occasionally spruce.

Outbreaks in these insect populations can occur rapidly, causing defoliation over hundreds of thousands of acres annually. In Idaho, WSB outbreaks have lasted up to 10-15 years; DFTM outbreaks usually collapse after one to two years.

These native forest defoliators are major components of the forest ecosystem in which they are found. They add to the biological diversity of the system, serve as food for other animals, and function in the release and recycling of nutrients.

Outbreaks of the insects can cause radial cially when other tree stressing factors, such as drought, occur in conjunction with defoliation.

In addition, outbreaks can affect stand structure, species composition and stand succession (Brookes, et al. 1978; Brookes, et al. 1985). Forest resources affected by these outbreaks include recreation, visual quality, wildlife habitat and timber.

Western spruce budworm and DFTM populations are currently at low levels in Idaho, causing no discernible defoliation. The last WSB outbreak peaked in 1986 at nearly 3 million acres of defoliation. That outbreak dropped sharply by 1988, and no WSB caused defoliation has occurred in Idaho since 1992 (Beckman 1996).

Similarly, the latest DFTM outbreak occurred during 1990-1992 in southern Idaho, where it caused defoliation on more than 400,000 acres of forested land and resulted in high levels of Douglas-fir and grand fir mortality (Weatherby, et al. 1997).

Implications

While WSB and DFTM populations are currently at low levels, recent monitoring shows they may be building up. Forest conditions over much of the state remain favorable for future outbreaks of these insects.

In general, dense, uneven-aged, mature stands of Douglas-fir and/or grand fir are at high risk to future outbreaks. Particularly vulnerable are those stands growing on warm, dry sites. Silvicultural practices, such as prescribed fire, timber harvesting, and thinning, can reduce the risk, if they are implemented to reduce the composition and structure of susceptible forest stands.

Implications for Native Insects & Diseases

Each of the agents previously described is part of a healthy, functioning ecosystem. When they function outside the objectives the landowner desires or what the ecosystem can sustain, they can become problematic.

Undesirable or unsustainable levels of native insects and diseases are actually an indicator of forest composition and structure that are undesirable or unsustainable. Much of the current composition and structure of Idaho forests has agents producing unacceptable changes for some landowner objectives, like the root rots in northern Idaho or multi-storied stands of Douglas-fir and grand fir that have the potential for unacceptable outbreaks, of spruce budworm, as examples. Landowners and managers have the choice of using various management techniques such as planting trees, prescribed fire, mechanical treatments like logging or mechanically thinning the forests to provide a mix of forest composition and structure that is sustainable.

Fire

Idaho's forests evolved with and adapted to fire. All are in some way "fire dependent." Reduced fire frequencies, the result of suppressing natural fire starts combined with the elimination of native American burning during much of the current century, have altered forest compositions and structure.

Fire is a normal part of the forest ecosystem and is essential to sustaining forests. It functions to reduce surplus biomass, recycle nutrients, set the stage for regenerating forests and in combination with other disturbance mechanisms maintains a diverse forest landscape.

Yet, severe stand replacing fires over large areas may be incompatible with our current human settlement and uses of the forest. Such large severe fires threaten human lives, buildings, air quality, wildlife, wildlife habitat, timber, water quality and quantity, and recreational opportunities. In addition, when such fires occur on the steep granitic soils of central Idaho, they can cause serious erosion and landslides that further threaten human lives, buildings and natural resources.

Historically, fire patterns varied greatly in different locations (Arno 1980). In forests at lower elevations and on dry sites at middle elevations where ponderosa pine was once the major forest component, fire intervals averaged 6 to 35 years (Steele et al. 1986; Arno 1988).

These fires usually burned the understory and maintained forests in an open park-like condition with grassy undergrowth. Here, forests were primarily made up of large, widely spaced pine and larch, which had thick bark and were fire resistant. Occasionally the fires were more severe and would kill much of the forest

In forests at higher elevations and in moist, middle elevations, fire intervals were longer, ranging from 40 to 200 years (Arno 1993). In these areas, fire was generally two types, mixed severity where it created a mosaic of forested conditions, in parts of the burned area some fire resistant trees survived, but the understory and thinned barked trees were burned, in other portions very little was affected.

The fires that killed only part of the forest are very important in the development of many old-growth forests in the moist types (Atkins 1996). The second type of fire at these higher elevations was stand replacement, in which essentially all the trees were killed. In the Northern Rockies, stand replacement fires commonly occurred in western white pine stands on the average every 150-200 years (Zack and Morgan draft). These were often in hot dry years or fires driven by strong wind events or both.

However, many decades of fire prevention, fire suppression, and timber harvesting have changed the fire regimes throughout the western United States, including Idaho. Our suppression efforts have been, until recently at least, quite successful.

There is growing concern that we are becoming less successful in our suppression efforts, as fuels continue to accumulate in unburned and otherwise unmanaged parts of the landscape. Furthermore, many now question the ecological desirability of suppressing all fires, especially surface and mixed severity fires.

Many forested areas now have high fuels, given the accumulation of trees and dead wood in the forest from decades of fire suppression, and are considered at risk of severe wildfire. When lightning storms ignite multiple fires in dry weather cycles control becomes extremely difficult and expensive and can cover large areas. In the dry forest types, fires can be more severe than in the past.

Since 1984, the number of acres burned annually by forest fires have increased substantially in Idaho. (O'Laughlin 1993.)

Implications

Unless fire-susceptible conditions change, we can expect similar large forest fires to continue to occur. Landowners and managers have a number of tools available to alter these conditions:

- Prescribed fire, both those resulting from lightning and human ignitions, are used to reduce the amount of fuel, prepare sites for the regeneration of new forests, and create more diverse forest structures, including old growth. The result can reduce the level of risk from some insects and pathogens and encourage diversity of wildlife habitat.

- Timber harvests can be designed to accomplish similar results as prescribed fires. The use of harvests in combination with fire can be very effective in changing the pattern of vegetation across the landscape to more desirable conditions. Figure 18 shows an area that was thinned prior to a wildfire and how it changed the pattern of the fire's behavior.

Figure 18. Boise National Forest.

The area on NFS lands currently being burned or harvested to provide for regeneration remains below that needed to maintain seral fire-dependent species.

Negative effects of burning include the risk the fire could escape, produce smoke that can adversely affect human health, and adversely impact the aesthetics of the airsheds. Harvesting generally requires some road building, which increases the potential for increased sedimentation and presence of potential barriers to fish movement.

To mitigate the negative impacts of fire and harvesting, care in design and implementation of management activities is needed to sustain proper functioning of the ecosystem.

Biodiversity

In Idaho, threatened populations of a few prominent species, such as the grizzly bear or woodland caribou, serve to highlight the larger issues of species diversity. Biodiversity may be viewed as a subset of forest health known as "habitat health."

Sustained healthy habitats for wildlife, vascular plants, and non-vascular plants (e.g., lichens, fungi, and bryophytes) is an important measure of all plant communities, including forests. Biodiversity is, therefore, a critical forest health issue. However, it remains a difficult element to measure.

In Idaho, broad-scale species diversity has been most affected by human interventions in disturbance regimes, such as where fire suppression and some timber harvest patterns and prescriptions are evident. Exotic plant, disease, and insect introductions also influence species diversity.

Many of these interventions and introductions have been discussed in previous sections of this report. Often these components work together to limit the amount and diversity of native species populations.

In terms of forest landscapes, native diversity is best maintained with a variety of forest type and stand structure conditions. While old-growth forest may support a greater diversity of species at one location, landscape diversity is best supported by a strategy that provides a mixture of age conditions from young to old (Halpern and Spies 1995). The challenge is maintaining the mix of young, mid-age, and old forests which supports diversity across the entire landscape.

Previous management practices in this region have affected successional stages overall by reducing the percentages of young and old stands, while increasing the percentage of mid-age forests (Langner and Flather 1994). Furthermore, great reductions in some forest types, such as western white pine, aspen, and ponderosa pine, will likely result in reduced regional diversity through the loss of plant and animal communities which thrive in these forest types.

Implications

Several tactics are used to maintain biodiversity: (1) Rare plants or animals are listed as threatened or endangered and plans are developed to enhance their habitat. (2) Habitat conservation areas are established to maintain viable populations at various scales. (3) A variety of forest types and structures across a landscape are maintained. This last strategy, in conjunction to a lesser extent with the previous two, is aimed more at sustaining plant and animal communities, rather than individual species (Merrill and others 1995).

Tactics 1 and 2 are referred to as "fine filter" approaches to conservation of diversity. The third is called a "coarse filter" approach, designed to provide a whole range of habitat conditions to sustain most species.

The fine and coarse filter techniques are best used in combination, since funds and knowledge are insufficient to manage species solely using the fine filter approach (Hunter 1990). Reliance only on the fine filter approach also may result in management that is in conflict with the coarse filter approach and vice versa.

Management Implications

The issues identified in this report are a product of monitoring, research and management experi ence. For a land manager or owner, what can be done to address those issues? How can the ecologic integrity of forests be restored so that the land can meet individual and diverse objectives?

The loss of integrity can be traced largely to three actions:

1) Addition of foreign agents. Exotic plants, pathogens, insects and other agents can profoundly affect ecosystems. Examples in Idaho include white pine blister rust and a growing number of noxious weeds. These agents now threaten a number of native species.

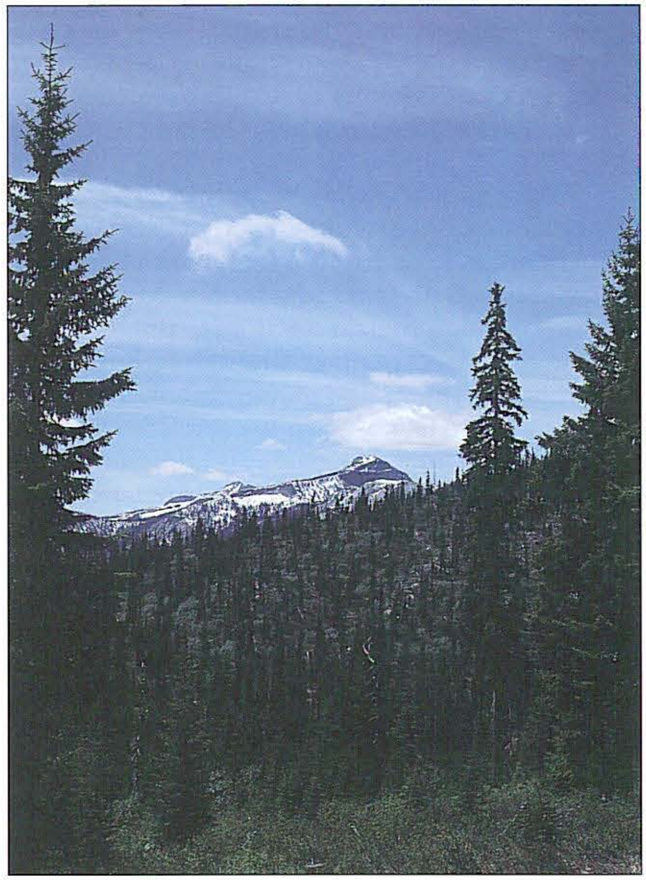
2) Withholding fire. Fire is a key process in the western "fire adapted forests". Without fire, forests continue to change with pathogens and insects playing a larger and different role. Fire prepares the site for regeneration of the shade intolerant species. The trend is loss of these species that were historically most abundant, and increase in medium-sized forests of shade tolerant species. It appears that forests are becoming less diverse and more homogeneous.

3) Direct influence. Humans have directly affected forests by harvesting, mining, road building and other forms of development. Harvesting, especially selective harvest of high-value trees, has decreased the amount of shade-intolerant pines and western larch, and reduced the amount of older age forests.

These changes and others occurred for several reasons:

- Information was lacking on how forests would respond to these human influences. Monitoring and research during the past several decades has put us in a better position to predict the effects of our actions.

- Some management practices instituted for desirable goals ended up producing other unforseen, undesirable results. An example, was the past practice of removing or burning most of the woody debris after a harvest to reduce the risk of wildfire. We have since learned this can deplete some nutrients and remove habitat for some animals important to the proper function of a healthy forest. Adjusting management activities to respond to new information and knowledge when things go wrong can minimize and mitigate the effects of unanticipated consequences. Such response is referred to as "adaptive management."



- Public values changed. Practices that were tolerated, even seen as desirable, are now considered unacceptable. Also, there is no public consensus on what values should be used to manage forests. Given that situation, the wisest management policy might be one which maintains options where possible.

It is clear that some changes in management policies and practices will be needed. Inaction or passive management will allow some of the problems to worsen. Managment actions implemented using our understanding of forest functions, like fire regimes, seems to be a prudent course to pursue (Quigley and others 1998).

Much remains to be learned, but strategies are being developed that offer promise (Everett and Baumgartner 1995; Sampson and Adams 1994). Each particular landscape has a different solution or combination of solutions depending on the type and number of health problems that exist and the values for which the land is managed.

Solutions to these health problems involve a combination of management activities: (1) prevention, to keep exotic species from becoming established or spreading farther, to prevent wildfire through fuels reduction, to prevent disease and insect damage through hazard reduction; (2) integrated management, to deal with exotic agents now firmly established, to reestablish appropriate levels and functions of native insects and diseases; (3) suppression, of fire, diseases and insects when the alternative is unacceptable; (4) restoration, of damaged watersheds, of fire in the ecosystem, of tree species and structures that have become scarce; (5) monitoring, to track broad vegetation trends, to evaluate the effectiveness of treatments, make adaptations as we contine to learn, and to detect emerging problems.

All of these elements that address forest health problems require using our current understanding of how ecosystems work and what objectives are to be achieved. Many of these forest health issues have developed over a period of decades and will require commitment to long-term activities or projects to restore forest health. Other issues can be addressed in relatively short periods of time.

Summary

Our goal is to provide information on the condition of Idaho's forests so that people can make informed management decisions. Our intent is to provide pertinent data that can be used to develop public policy and guide management programs to restore and maintain forest health conditions consistent with societal and landowner values.

Some of Idaho's forests have been altered dramatically by a century of intensive use, such as mining, conversion to agriculture and logging. Other human activities, including fire suppression and the introduction of non-native species, also have produced profound changes.

Aggressive fire suppression was instituted to protect the value of forests for commodities and to protect watersheds from flooding and from sediment produced after fires had occurred. Large wilderness and roadless areas that people think of as pristine have been influenced by this policy as well.

It is clear our past land use practices have brought significant changes to Idaho's forests. If we assume that it is desirable to maintain native tree species and, at a minimum, representative areas with historic stand structures, we must conclude past actions have had a negative effect on achieving this objective. Several tree species, such as western white pine, aspen and ponderosa pine are much reduced from what they were historically, especially in large size classes.

On the other hand, some forms of management have replaced or complemented the stand replacement or thinning effects of wildfire. For example, commercial thinning has reduced densities in ponderosa pine forests. Logging, followed by planting rust-resistant western white pine, provides the potential to restore that species in significant amounts.

While wildfire suppression was successful in reducing the loss of timber and human life, it allowed stand densities to increase and successional change to occur favoring shade-tolerant forests.

Current information and modeling projections indicate that changes in forest types and structures will continue under current management practices. Intermediate and regeneration harvesting and prescribed fire are increasingly used to reduce stand densities, to reduce the probability of severe fires, and to favor shade-intolerant species.

To reverse the downward trend of western white pine, western larch, and ponderosa pine forest types will require active management (Hann and others 1998). It would include more actions that regenerate a new forest such as prescribed fire or logging.

We have learned much about our forests, about their response to our actions, and about the ways in which they continue to change with and without active management. This information can be used in the formulation of policies and prescriptions to make treatments more predictable and effective than in the past.

Pathogens, insects, and, periodically, wildfire continue to influence managed and unmanaged forests alike. The management challenge is to judiciously influence the direction of change toward maintenance of desired conditions based on landowner objectives.

The forest health monitoring program with its long-term focus, can help detect and evaluate changes in our forests and the effectiveness of current management policies. That information can then be used by owners, managers and public policy makers to identify opportunities to mitigate undesirable changes.

FOREST HEALTH ISSUES

Summary

Some forest health issues offer clear management alternatives, while others do not. Although the problem of introduced pests is severe, there are remedies available to us.

While additional introductions may be inevitable, given modern travel and trade, many pests can be prevented or deferred through quarantine and other measures. Agents that have become firmly established can be dealt with using integrated pest management practices.

In the case of white pine blister rust, restoration includes gene conservation, continuing to reforest with rust-resistant and potentially resistant white pines, monitoring their performance, and maintaining support of research and tree improvement.

The types of forest communities present in Idaho have changed significantly during this century. The decrease in the amount of western white pine, ponderosa pine, western larch, aspen, and whitebark pine is profound evidence of these changes. Insects and pathogens have always been important sources of forest dynamics, however they have become the primary source where fire has been excluded and no other management treatments have been substituted. The effects of insects and pathogens on forest composition and structure is very different than fire (Byler and others 1996,). The insects and pathogens accelerate forest succession towards shade tolerant, shorter-lived species, where fire usually favors the establishment of the intolerant, long-lived species, listed above (Hann and others 1998).

Formulating the proper role of fire to restore and maintain forest health will continue to evolve. Fire is essential to sustaining forests as we know them, yet fire, at least in some locations and amounts, is incompatible with current human settlement and uses of the forest. There are risks to people and property, and the aesthetics effects of smoke and the effects on human health remain issues to be addressed.

Thus we face choices. Where and when will we use fire to accomplish ecological or resource objectives? Can we accept the risks and undesirable effects associated with its use? Where will we use harvesting or other forms of management to replace the lost function of fire in regenerating with shade-intolerant species?

Watersheds, which have been impacted by human activities, will continue to be a key element in maintaining forest health. A better understanding is needed about the relationship of vegetative conditions and water quality. We also need to use what information is available to develop strategies that will bring long-term health to both watersheds and forests. Active restoration is needed for both, if they are to provide their potential benefits.

Human development in the wildland interface present especially sensitive management problems. Wildfires can lead to losses of property and human life. Insects and pathogens can cause changes that make forests less desirable or transform trees into safety hazards.

Problems in the wildland interface will only increase as development accelerates in many parts of the state. Outstanding issues for residents involve personal values, personal safety, and personal property. In part, acceptable solutions can only be found when individuals and communities in the urban/forest interface and forest managers explore the issues together. However, individual landowners can take actions to protect life and property from destruction by fire, insects, or pathogens by changing the density and species mixture through prudent harvesting or burning.

Maintaining biodiversity offers no easy resolution because any action, including no action, can produce both positive effects for some species and negative results for others. Efforts to conserve individual species will continue. But it also appears prudent to include, as a broad objective, the maintenance or restoration of representative forest types and structures on Idaho's landscape that can provide for countless other species.

Conclusion

In taking a broad view of the evolution of Idaho's forests, we find that major changes have occurred during the past century. These changes have significant implications for forest health and sustainable productivity of goods and services we expect from our public and private forests.

We conclude with three points:

- Forests change whether we intend them to or not. Our actions will be more effective if we better understand and anticipate those changes and consider them in our management strategies designed to reach desired conditions.
- Humans will continue to impact Idaho's forests, for better or worse. Forest managers and individual landowners will have to resolve what level of change is acceptable to provide a future supply of goods and services and safeguard forest health.
- We should consider the implications of the current vegetation trends on those elements we value from Idaho's forests, so we can formulate our actions to produce desired conditions.

Much of the forest health debate to date has focused on "tradeoffs"—timber versus wildlife, roads versus water, etc. We have seen, however, that there can be common ground among segments of the public. There are trends that demonstrate undesirable or "unhealthy" conditions for several types of resources. We think there can be actions taken that benefit a variety of values, whether we are considering private land or publicly owned land.

The first step to achieve a desired condition is to define it. And in that determination, landowners and society play a role. With shifts over the past few years in public values from a largely consumptive use of forests to a greater emphasis on other values, it follows that desired forest conditions should reflect that change.

The following questions apply to individual, corporate and public landowners. What key values do we want our forests to serve? What kinds of forests do we want to leave for future generations? What combinations and arrangements of forest types and structures can best provide for present and future needs? What can be accomplished ecologically, economically and politically to achieve and maintain desired forest conditions?

When we reach some agreement or accommodation on what conditions are desired, we can begin to make progress in formulating long-term policies and strategies for achieving those ends.

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Appendices

Appendix A

SUMMARY OF THE 1996 FHM PLOT SURVEYS

The two graphs below describe the variety and amount of species tallied in the forested overstory and understory (Figure A1 and Figure A2).

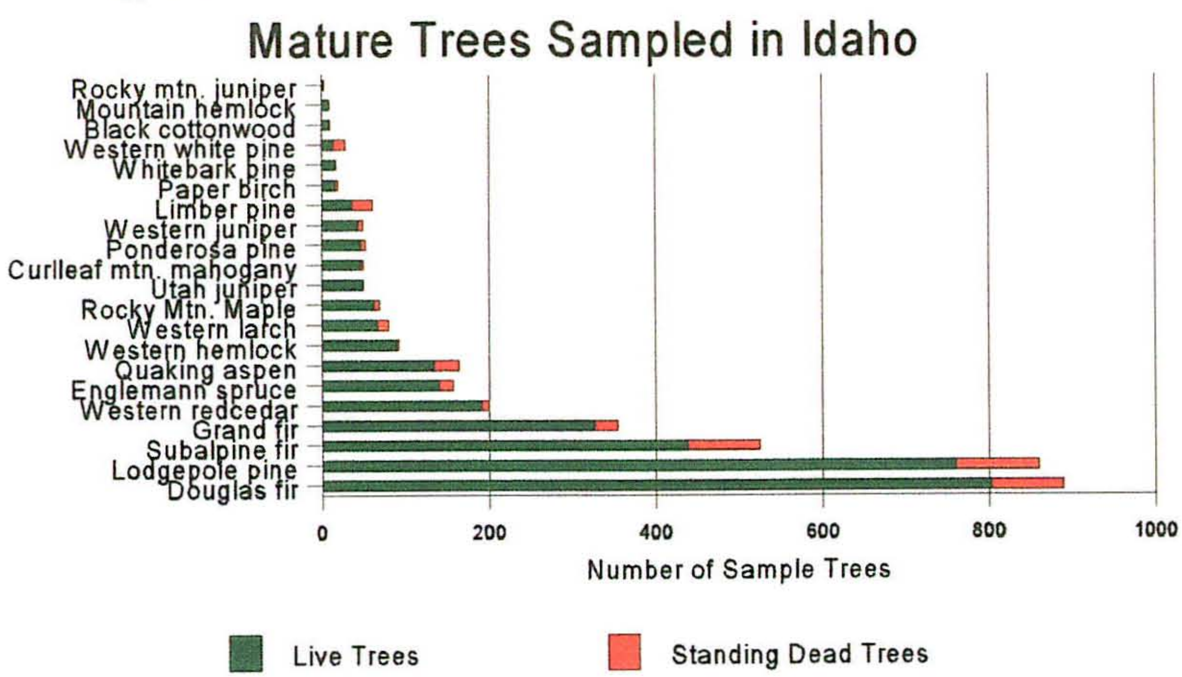
A review of the total mature tree tally shows the predominance of shade tolerant species in Idaho, with the exception of lodgepole pine. This data is consistent with Brown and Chojnacky (1996) and other information presented elsewhere in this report

In terms of regeneration, the large amount of Rocky Mountain maple is probably due to the prominent growth form this species exhibits (Figure A2). Saplings and seedlings compose most of the total tally because maples in this location may grow as multi-stemmed "shrub-like" forms for decades before they become tree size.

In terms of age, Rocky Mountain maples are not true seedlings, although they are categorized as such because of their size. Also, note that the ratios between saplings and seedlings of different species vary widely. This disparity may be attributed largely to their different reproductive strategies. For instance, subalpine fir produces hundreds of seedlings in order that a few may survive. However, in subsequent years this initial density of regeneration may be thinned substantially due to limited light and water resources. Although ponderosa pines produce fewer seedlings than do firs, the pines have better survival rates due largely to completely different reproductive strategies.

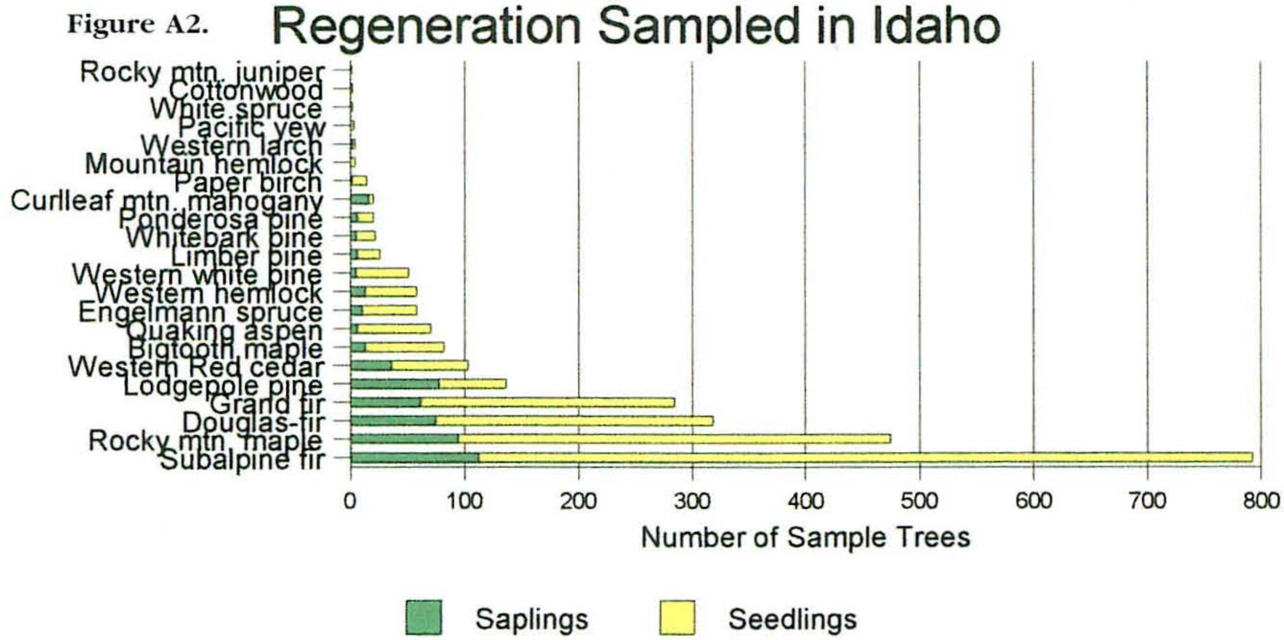
In addition to the tree tally, each mature live tree was sampled for current crown conditions. Visual crown assessments are made to determine changes in crown conditions resulting from a variety of causal agents. Long-term monitoring of crown conditions, especially near point sources of pollution, are good indicators of general forest conditions. Visual Crown Ratings (VCR) consist of estimates of crown dieback, crown density, and foliage transparency. Figures A3, A4, and A5 depict the current crown conditions across all plots in the state. The following paragraphs explain these readings in more detail. Future readings of crown variables can be compared to current values to look for

Figure A1.



* Mature Trees are those greater than 5.0 inches diameter at breast height or root collar.

Figure A2.



shifts in crown conditions by species, or by overall tree population over time.

Dieback is a measure of the percent of the tree crown that has died from the branch tips inward, toward the center of the crown. From Figure A3, it is clear that most Idaho trees have very little dieback. In fact, very few trees (1.6 percent statewide) have dieback in greater than 25 percent of their crown. Hardwoods showed a markedly higher dieback rate than the overall dieback, having 9 percent of trees with greater than 25 percent dieback, however, the sample size for hardwood trees was much smaller and therefore a little less reliable.

Figure A4 depicts the current state of foliage transparency on FHM plots in Idaho. Transparency is the percent of light that passes through the foliated portion of the crown, excluding tree branches and main stems. A tree with a rating of "0" or "5" percent transparency allows either no light, or very little light, to pass through the leaves to the forest floor. In general, when trees are unhealthy their crowns begin to thin out, allowing more light to pass through. The bar graph of foliage transparency, similar to crown dieback, is highly skewed to the lower percent values. In

Figure A3.

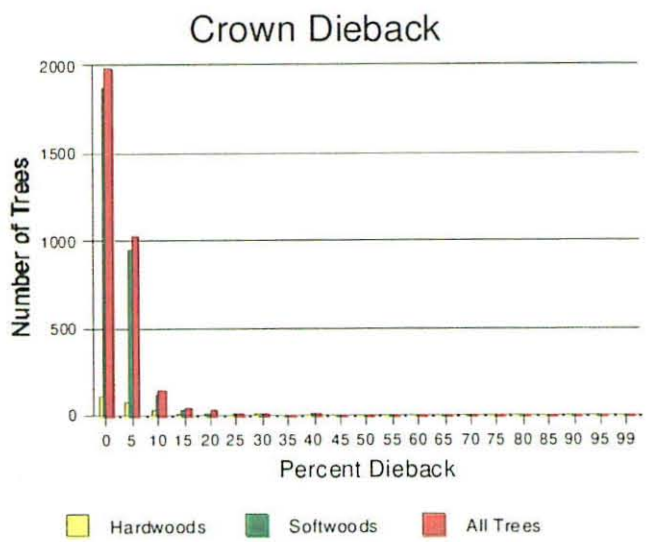
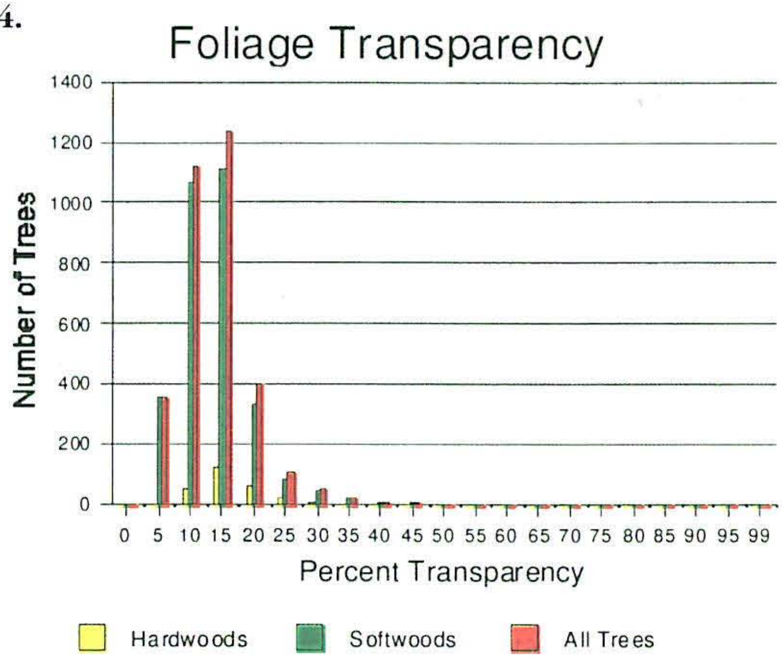


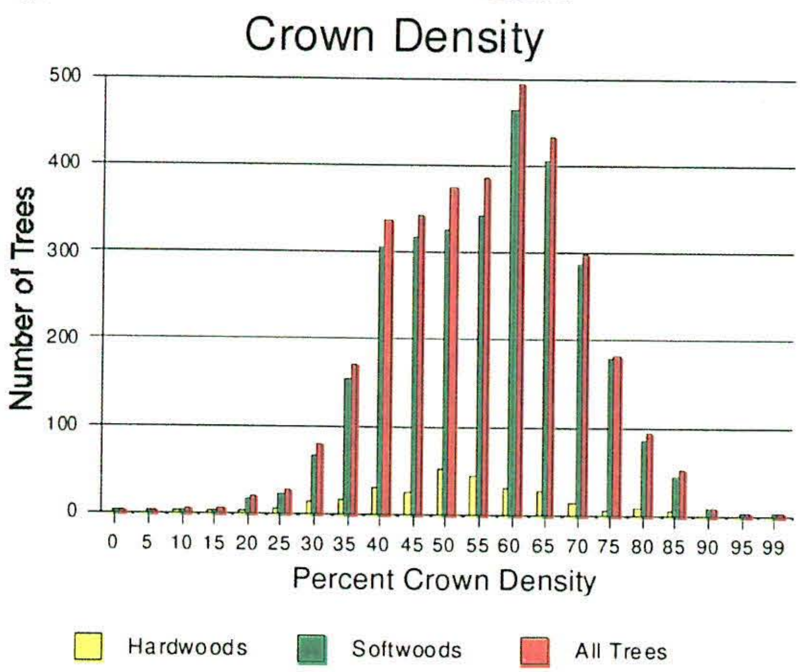
Figure A4.



terms of all trees, only 2.7 percent have transparency ratings of more than 25 percent. Hardwoods and softwoods have received about the same transparency ratings that were greater than 25 percent of the crown (2.9 and 2.6, respectively).

Crown density is determined by estimating the percent crown area that blocks light from passing through. This rating does include woody parts of the tree, so this is not a reflection, or subtraction, of foliage transparency. As seen in Figure 24, crown densities for hardwoods are slightly lower, overall, than those of softwoods, although the sample size for hardwoods in Idaho is much smaller. Of particular concern in future readings will be movements away from the middle of this graph by any species groups. Currently, 94 percent of all trees are from 25-75 percent density ratings. A greater percentage of hardwoods are below 25 percent, while a greater percentage of softwoods are over 75 percent. Low density crowns may signal declines in growth from a variety of causal agents. Very dense trees may be unhealthy as well. For example, many conifer species "broom up" as a result of mistletoe infection.

Figure A5.



Distribution of forest land (% forested plots in Idaho by forest type and plot-level categories, 1996.

Stand-level category	% of plots	Stand-level category	% of plots
Forest Type Group		Seedlings/Acre	
Douglas Fir	32.33	0 - 999	65.92
Ponderosa Pine	3.53	1000 - 1999	17.03
Lodgepole Pine	13.96	2000 - 2999	8.33
Spruce/Fir	15.59	3000 - 3999	2.08
Grand Fir/White Fir	14.69	4000 - 4999	1.51
Spruce	1.51	5000 - 5999	1.51
5-Needle Pines	0.76	6000+	3.60
Misc. Sfwd. Timber.	6.80		
Aspen	3.12	Snags/Acre	
Misc. Hrwd. Timber.	0.76	0	30.64
Pinyon-Juniper	3.21	1 - 24	44.95
Misc. Hrwd. Wdld.	2.29	25 - 49	14.83
Other Timberland	1.14	50 - 74	5.79
		75 - 99	2.27
Stand Origin		100+	1.51
Natural	97.64		
Planted	2.36	Basal Area/Acre	
		0 - 39	24.72
Stand Size		40 - 79	19.06
Sawtimber	66.48	80 - 119	20.83
Poletimber	23.48	120 - 159	13.13
Seedling/Sapling	8.60	160+	22.25
Non-Stocked	1.45		
Stand Age			
0 - 50	20.85		
51 - 100	50.59		
101 - 150	23.72		
151 - 200	4.03		
201 - 250	0.81		

Distribution of damage types by species for trees (5 dbh and larger) on Idaho Plots.

	Trees with no damage (%)	# Damages recorded	Cankers	Conks and decays	Open wounds	Resinosis	Broken bole	Brooms on bole	Broken roots	Loss of apic. dominanceBroken roots	Broken branches	Excess branching	Discolored foliageExcess branching	Other
Softwoods														
Douglas-fir	695 (87)	126	4	32	8	6	1	0	0	45	12	18	0	0
Ponderosa Pine	41 (87)	8	0	2	1	0	0	0	0	2	1	1	1	0
Lodgepole Pine	561 (74)	237	28	43	81	3	1	2	0	31	4	32	11	1
Subalpine Fir	366 (84)	86	11	22	14	2	0	1	1	25	5	4	1	0
Englemann Spruce	119 (88)	20	1	3	3	5	0	0	0	6	2	0	0	0
Other Softwoods	663 (88)	100	3	39	12	1	1	0	2	30	4	0	7	1
Softwood Woodland	83 (86)	17	0	9	1	1	0	0	0	1	1	3	1	0
Subtotal, Softwoods	2528 (83)	594	47	150	120	18	3	3	3	140	29	58	21	2
Hardwoods														
Aspen	52 (38)	107	48	32	7	3	0	0	0	11	6	0	0	0
Cottonwood	9 (100)	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Hardwoods	13 (38)	9	0	2	1	0	0	0	0	4	2	0	0	0
Hardwood Woodland	74 (67)	48	0	12	3	0	1	0	0	3	28	0	0	1
Subtotal, Hardwoods	148 (54)	164	48	46	11	3	1	0	0	18	36	0	0	1
Totals	2676 (81)	758	95	196	131	21	4	3	3	158	65	58	21	3

* # of damages recorded may include multiple damages, up to 3, for individual trees

Appendix B

For more information related to forest health contact:

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